POWER PLANT ENGINEERING

Established Over 31 Years

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Midnight in a Diamond Mine

DRAMATIC MOMENTS occur often in a diamond mine, as you will note in the above photograph, which was taken at midnight on a rainy Thursday in September. Note the nervous tension under which the men are working, especially the one at the controller, as they search frantically among the diamonds piled on the traveling table. They are looking for bolts, pieces of timber, rock and the like, which must be removed. For, when these diamonds are sent to the pulverizers or stokers in the boiler house—Huh? Why, of course, we burn diamonds! Sure, black diamonds!

Anyway, all kidding aside, these black diamonds are the raw material that forms the basis of all power plant work. Of course, you've got to get every possible heat unit out of them and convert it into mechanical or electrical energy with the smallest possible loss. And to do this you must use every resource of modern engineering as embodied in the equipment described in this issue. But all of these things exist solely because those black diamonds must be burned.

Attention must be given to every detail of the design, construction and operation of power plant machinery. The photograph shows how this attention to detail is carried right back to the source of the coal itself, which is run over the picker table where all foreign material is removed.

National Lock Company Installs Two Extraction Type Turbines

EXTRACTION TYPE TURBINES, COOLING TOWER, GRAVITY ASH HANDLING SYSTEM, WATER SOFTENER AND COMPACT ARRANGEMENT OF AUXILIARIES AND PIPING FEATURE THIS RECENTLY COMPLETED INDUSTRIAL PLANT

TO MEET THE INCREASING power needs of an expanding industry, the National Lock Co. of Rockford, Ill., deemed it advisable to abandon its old power plant, surrounded by factory buildings, and build a new one. Consequently the reciprocating engines which gave constant service for many years have been replaced by new extraction type turbines housed in a modern isolated power plant with liberal space allowance for present equipment, coal storage and future expansion.

Three Connelly boilers supply steam for power and industrial purposes, under normal conditions the industrial requirements being taken care of by steam bled from the first stage of the two General Electric turbines. Water supplied from wells is treated by a hot process softener for use as boiler makeup, or used raw in a cooling tower for condenser circulating water.

FUTURE EXPANSION PROVIDED FOR IN DESIGN

At present space is provided for but one additional boiler although the entire plant is laid out with the intention of ultimately doubling the capacity. All piping is below the floor level, the arrangement, well illustrated in Fig. 8A, adding materially to the general appearance. The chemical tank, sedimentation tank, filter and pumps of the water softener are directly behind the boilers, Fig. 1, while the feed-water heater and boiler feed pumps are in the turbine room as shown in Figs. 7 and 8B.

Both main and auxiliary steam headers, running transverse of the building, are provided with the auxil-

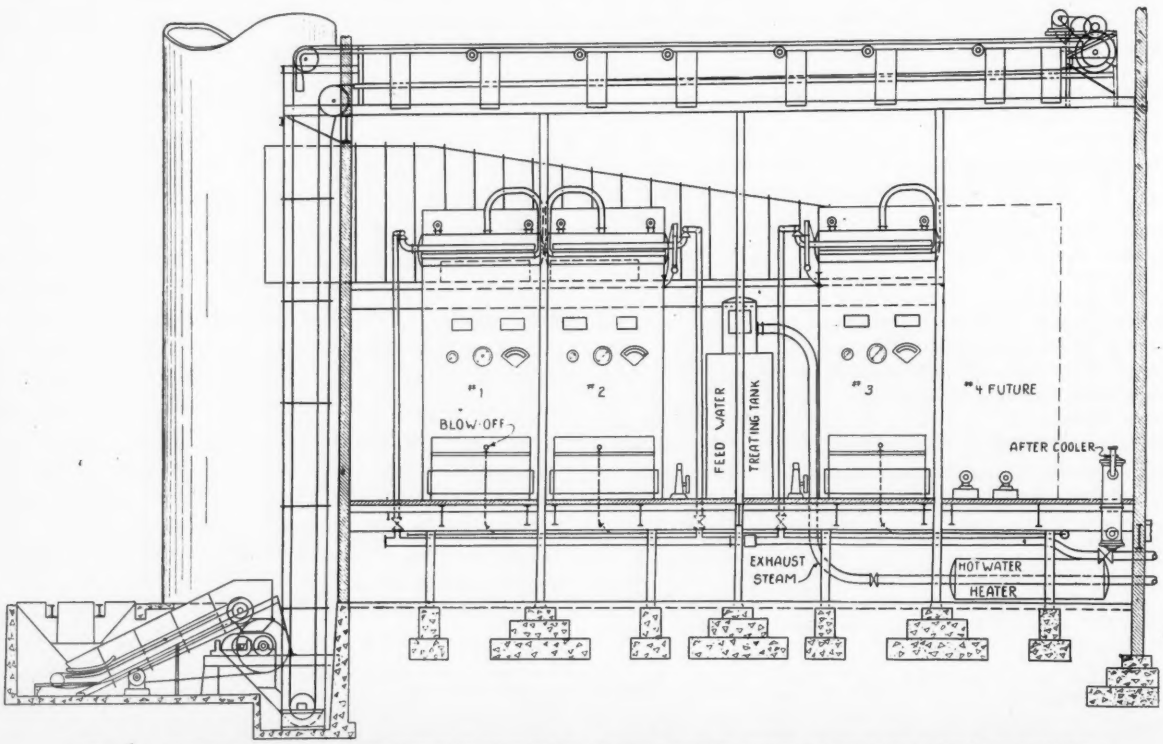


FIG. 1. WATER SOFTENER EQUIPMENT IS INSTALLED IN THE BOILER ROOM AT THE REAR OF THE BOILERS

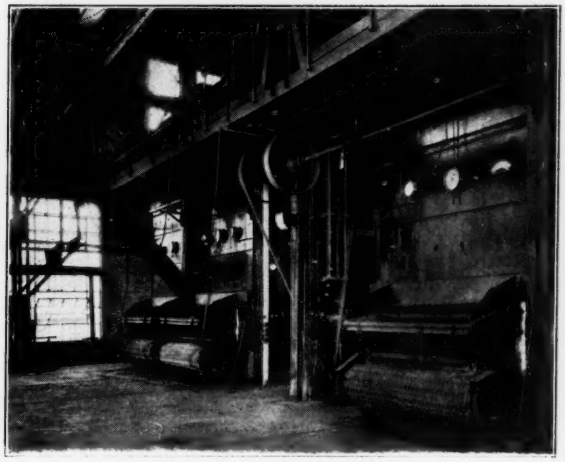


FIG. 2. EACH BOILER IS EQUIPPED WITH CO_2 AND STEAM FLOW INDICATORS IN ADDITION TO THE USUAL PRESSURE GAGE

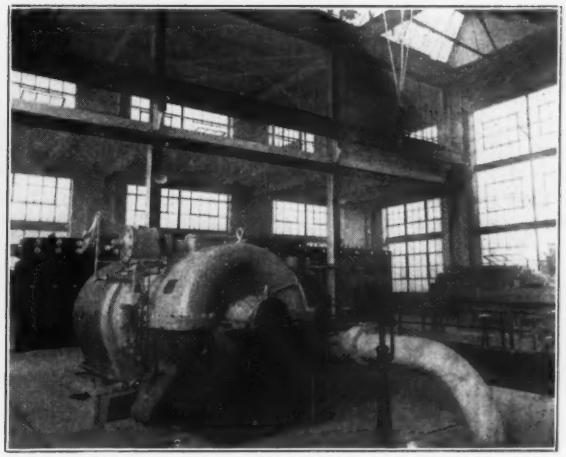


FIG. 3. THE TURBINE EXTRACTION VALVE CONTROL CYLINDER AND PILOT VALVE ARE SHOWN IN THE IMMEDIATE FOREGROUND

iaries, except the boiler feed pumps and standby exciter, located in the turbine room basement between the main condensers and turbine room-boiler room partition. This allows all auxiliaries to be supplied from one comparatively short header, the boiler feed pumps and steam exciter by leads up through the floor, the remainder by down-comers from the ceiling.

Auxiliary exhaust goes directly to the process steam header where the pressure is maintained at 2½ lb. by an R-K regulator with additional steam bled from the turbines. In case the electrical load is so light that the total auxiliary exhaust and turbine bled steam is not sufficient to supply the demand, live steam is automatically admitted to the system. Two R-K regulators, one reducing from 225 lb. to 100 lb. and the other from 100 lb. to 2½ lb. are used for this purpose.

Coal Is Ordinarily Crushed and Stored in the Bunker

As shown the boiler room elevation Fig. 1 and general plan, Fig. 9, as received in hopper bottom cars is ordinarily dumped into a track hopper, crushed in a double roll crusher and immediately elevated to the 400-t. bunker by a V bucket conveyor. From there it is distributed to the stoker hoppers by a 1000-lb. motor driven weigh larry. In case the coal is stored it can be reclaimed in an industrial car, carried to the track hopper, crushed and then elevated to the bunker.

This industrial track system also serves for ash disposal, the water sealed ash gates delivering the ash by gravity from the hoppers directly to the cars. A 30-t. ash hopper located over the standard gage tracks is provided with a 22 ft. bottom clearance so that railroad

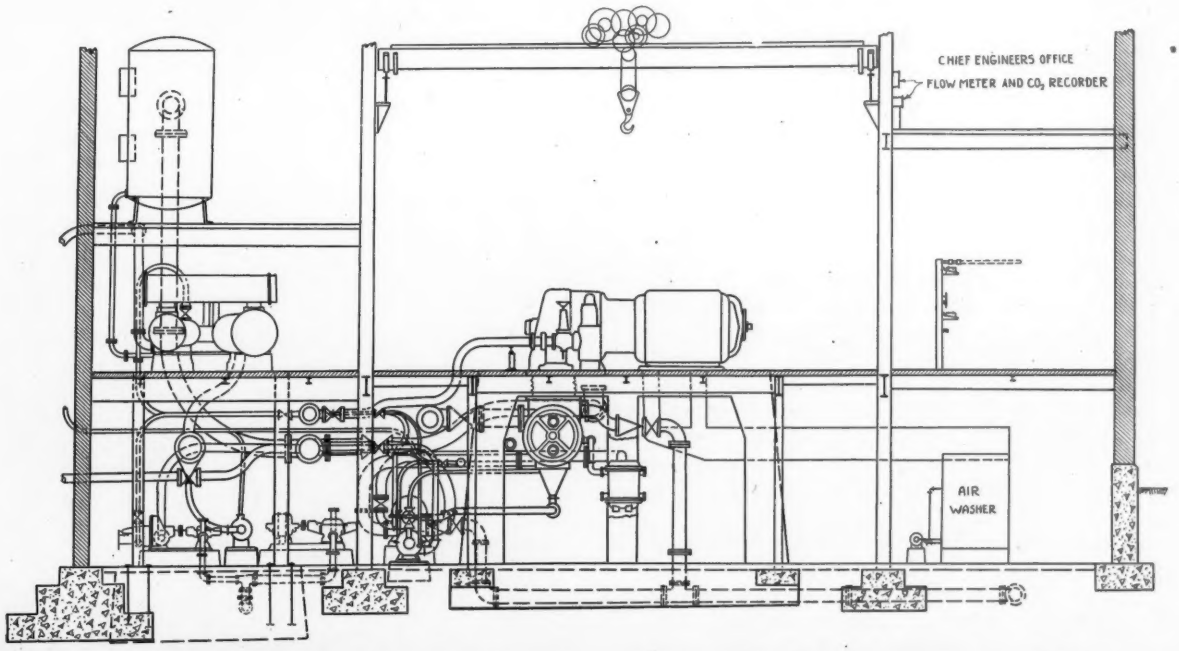


FIG. 4. LONGITUDINAL SECTION OF THE TURBINE ROOM LOOKING FROM THE 1250-KW. TOWARD THE 750-KW. UNIT

cars can be loaded by gravity. Ash is elevated from the industrial track hopper by the skip hoist shown in the background of Fig. 8C.

Cross sections of the boilers and settings are shown in Fig. 5. Boilers are the Connelly three-drum type, fired by Green chain grate stokers and provided with Detrick rear and front arches. The latter is of the convex-concave form and brings the throat of the furnace down to 4 ft. 6 in. Natural draft is supplied by a 265 ft. stack, 14 ft. in diameter at the bottom and 9 ft. at the top.

Ash Gates Operated by Low Pressure Steam

Cast-iron hoppers of gravity lock tile construction are used under the stokers. These are provided with

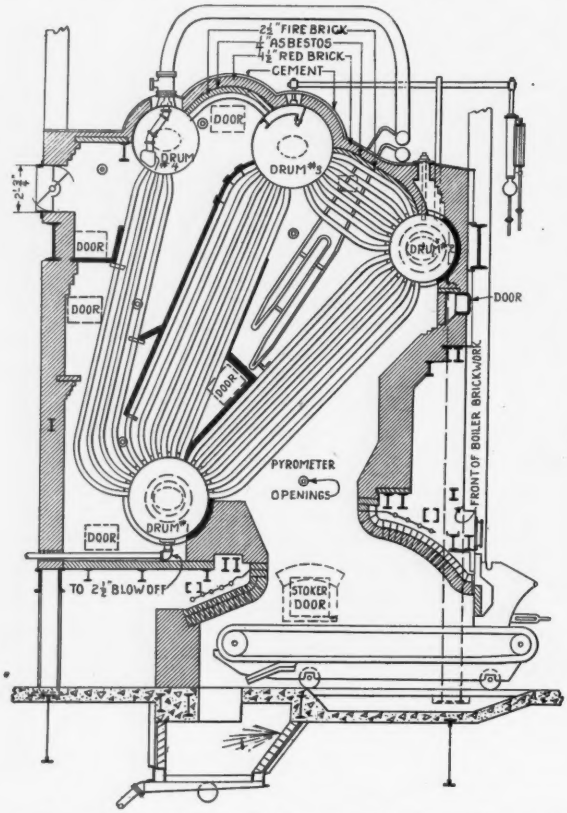


FIG. 5. EACH BOILER SETTING IS PROVIDED WITH FIVE PYROMETER OPENINGS FOR TEST PURPOSES

A. S. H. Type C water collecting gates. Each gate is 3 by 4 ft. and the two gates on each boiler are operated by one common 6½-in. cylinder. Originally it was intended to use compressed air, but it was later found advisable to change this and service steam at about 80 lb. is now used. Quenching jets in the front wall supply quenching water continuously in a fine spray, well distributed over a wide area. This water thoroughly quenches the ashes, eliminates the dust and forms a water seal to prevent air leakage.

Elesco superheaters with a heating surface of 267 sq. ft. of No. 9 B.-W. G. 1½-in. elements were designed to give 100 deg. superheat at 225 lb. pressure and 175 per cent rating. From the superheaters the steam lines drop vertically downward to below the floor and then to the rear to join the steam header.

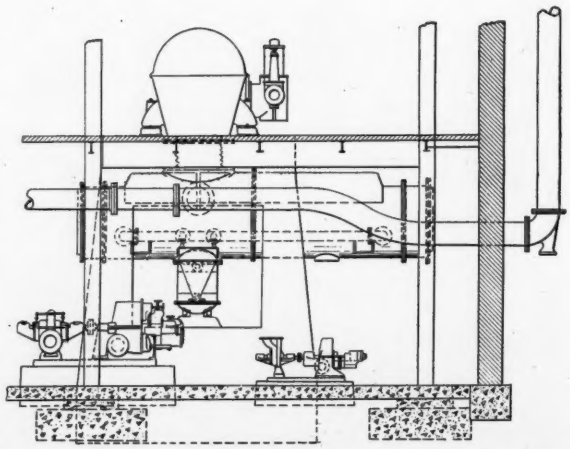


FIG. 6. CONDENSER AUXILIARIES ARE ALL STEAM DRIVEN

Feed water is furnished by two Cameron 250-g.p.m., 3-in., 2-stage centrifugal pumps, both driven at 3000 r.p.m. by 75-hp. Terry steam turbines. These pumps are set directly below the feed-water heater and have a normal head of 10 ft. on the suction. For standby or emergency use an injector is provided.

Clear Water Hotwell Takes Care of Fluctuations in Feed-Water Flow

Condensate returns from the condenser are piped through the ejector coolers direct to the open induction type feed-water heater and heated to about 204 deg. F. Makeup water is supplied from the softener system or from the clear water sump in the basement as operating conditions may determine. This sump with float controlled vertical pumps receives all clear water drips and overflow from the treated water and feed water system. Water for the softener is taken from

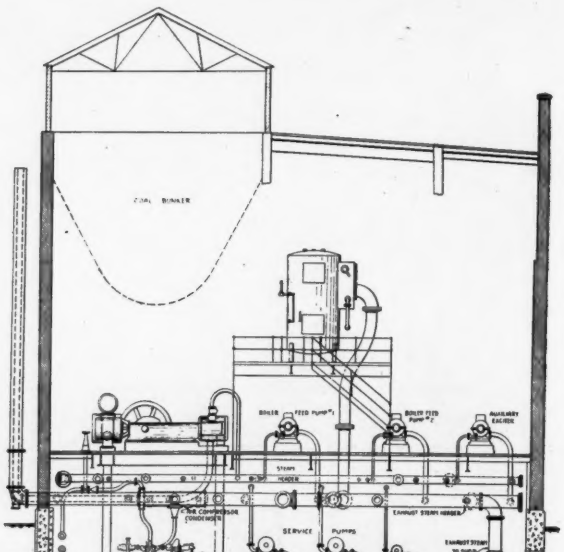


FIG. 7. THE OPEN FEED-WATER HEATER IS LOCATED IN THE TURBINE ROOM DIRECTLY OVER THE BOILER FEED PUMPS

the service lines and treated with lime; about 300 lb. a day is being used at present.

Service water, in fact all water used, is supplied from a 12-in. well although a city water connection is provided for emergency use. The well is approximately 275 ft. deep with an air lift well head placed about 15 ft. from the bottom. Air at 80 lb. is used for pumping, the total lift being about 50 ft. Water is pumped into an 85,000-gal. reservoir, 11 ft. deep. It is filled four times daily, pumping starting when the level drops to about 4 ft.

Air for the air lift and other service throughout the factory is supplied by an Ingersoll-Rand Co. 10 and 15 by 14 and 22 by 16-in., 80-lb., cross compound, two-stage compressor equipped with both inter and after coolers. The machine has a 245 sq. ft. surface condenser and is operated under a 25-in. vacuum. By means of a regulator some of the air is reduced to 65 lb. pressure for use on the shop system.

Air valves are not painted but all steam and water valves are painted red and white respectively and the operating valves for pipes below the floor provided with extension stems. Several of both types are visible in Fig. 8B.

Both turbines are of the automatic extraction type, each with a direct connected exciter and C. H. Wheeler Mfg. Co. surface condenser. The larger one, 1250 kw., is normally used and the 750 kw. used only for exceedingly heavy or light loads. Current is generated and distributed at 2300 v. through a 17-panel black slate switchboard. No fuses are provided, all protection being handled by circuit breakers. A 35-kw. turbine driven exciter is provided for standby service and is large enough to serve both generators.

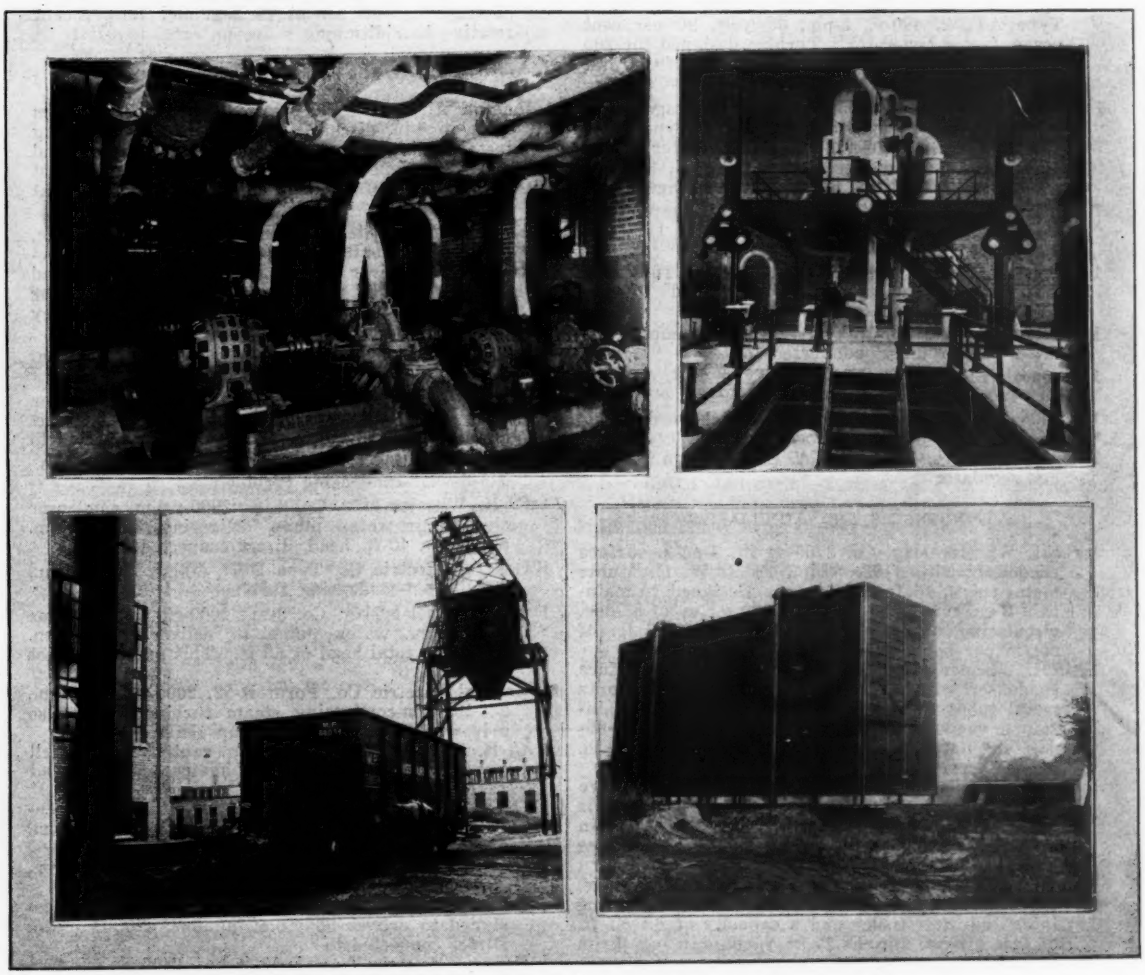


FIG. 8. VARIOUS INTERIOR AND EXTERIOR VIEWS OF THE PLANT

Condensers are of the three pass type with 5/8-in., 17 B. W. G. Muntz metal tubes. The larger one has a cooling surface of 3700 sq. ft. and was designed to maintain a vacuum of 27 in. with 2000 g.p.m. of 85 deg. water when condensing 25,000 lb. of steam per hour. The smaller one has 1172 sq. ft. to handle 15,000 lb. of steam per hour with 1200 g.p.m. of 85 deg. water.

Each condenser has a two-stage twin Radojet with surface inter and after coolers combined in a single shell. They have air handling capacities of 8.5 and 6.8 cu. ft.

of free dry air per min. at 27 in. vacuum with steam at 135 lb. gage. Both coolers drain back to the hotwell through a single shell vacuum trap drain control. Cooling water is supplied by the condensate pump with a C. H. Wheeler Mfg. Co. 25 by 70 by 35-ft. cooling tower guaranteed to cool 3200 g.p.m. from 108.75 to 85 deg. F. with air at 75 deg. F. and 75 per cent relative humidity.

Principal Power Plant Equipment at National Lock Company

Turbo-Generators and Exciters

1 General Electric Co. 1250-kw., Form C, 3-stage, 3600-r.p.m. automatic bleeder type turbine, driving a Type ATB-2, 480-v., 3-ph., 60-cycle, 80 per cent power factor generator. Turbine designed for 200 lb., 100 deg. superheat, steam to be bled from first stage.

1 General Electric Co., 750-kw., Form C, 3-stage, 3600-r.p.m., bleeder type turbine driving a Type ATB, 480-v., 3-ph., 60-cycle, 80 per cent power factor generator. Turbine designed for 200 lb., 100 deg. superheat, steam to be bled from first stage.

1 General Electric Co. 17-kw., 125-v., 136-amp., Type ED-2 exciter direct connected to the 1250-kw. turbo-generator.

1 General Electric Co. 12.5-kw., 125-v., 100-amp., Type ED-2 exciter direct connected to the 750-kw. turbo-generator.

1 General Electric Co. 35-kw., 125-v., 280-amp., Type CC-2 exciter direct connected to

1 General Electric Co. 35-kw., Type D-2, 225-lb., non-condensing steam turbine.

17 General Electric Co. black slate switchboard panels with instruments and

1 General Electric Co. Type TA, 125-v., Form P6 voltage regulator.

Condensers and Auxiliaries

1 C. H. Wheeler Mfg. Co. 3700-sq. ft., 3-pass. surface condenser with 1178, ⅝-in., 18 B. W. G. Muntz metal tubes, 16 ft. 2 in. long. Designed to maintain a vacuum of 27 in. with 2000 g.p.m. of 85-deg. circulating water when condensing 25,000 lb. of steam per hour.

1 C. H. Wheeler Mfg. Co. 2300-sq. ft., 3-pass. surface condenser with 1172, ⅝-in., 18 B. W. G. Muntz metal tubes 12 ft. 2 in. long. Designed to maintain a vacuum of 27 in. with 1200 g.p.m. of 85-deg. circulating water when condensing 15,000 lb. of steam per hour.

1 C. H. Wheeler Mfg. Co. 245-sq. ft., 2-pass surface condenser with 214, ⅝-in., No. 18 B. W. G. Muntz metal tubes 7 ft. 1 in. long. Designed to maintain a vacuum of 25 in. with 275 g.p.m. of 85-deg. water when condensing 2900 lb. of steam per hour.

1 C. H. Wheeler Mfg. Co. Size T. C. A. 25, 2-stage, twin Radojet air pump with combined surface inter and after cooler and a capacity of 8.5 cu. ft. of free air per min. at 27 in. vacuum, using steam at 135 lb. pressure.

1 C. H. Wheeler Mfg. Co. Size T. C. A. 20, 2-stage, twin Radojet air pump with a combined surface inter and after cooler and a capacity of 6.8 cu. ft. of dry air per min. at 27 in. vacuum, using steam at 135 lb. pressure.

1 C. H. Wheeler Mfg. Co. single-stage Radojet air pump with a surface after condenser and a capacity of 7.35 cu. ft. of free dry air per min. at 25 in. vacuum, using steam at 135 lb. pressure.

1 C. H. Wheeler Mfg. Co. 20 ft. wide by 70 ft. long by 35 ft. high natural draft cooling tower guaranteed to cool 3200 g.p.m. of water from 108.75 to 85 deg. F. with air at 75 deg. and 75 per cent relative humidity.

Pumps

1 Indiana Air Pump Co., Type DOA air lift system with an 8-in. discharge pipe, the well head being installed in a 12-in. well 260 ft. below the ground level. Designed to discharge 850 g.p.m. against a total head of 50 ft. when supplied with air at 85 lb. pressure.

2 A. S. Cameron Steam Pump Works, 3-in., 2 stage, 3000-r.p.m., centrifugal boiler feed pumps. Designed to deliver 250 g.p.m. against a total head of 600 ft. This pump handles 200 deg. F. water with a positive head on the suction of 10 ft. They are direct connected to

2 Terry Steam Turbine Co. 75-hp., 225-lb., non-condensing 3000-r.p.m. turbines.

1 C. H. Wheeler Mfg. Co. 8-in., 1750-r.p.m., condenser circulating water pump to deliver 2000 g.p.m. against a total head of 40 ft. Direct connected to

1 General Electric Co. Type D-54, 50-hp., 1750-r.p.m., 225-lb. non-condensing turbine.

1 C. H. Wheeler Mfg. Co. 6-in., 2000-r.p.m. condenser circulating water pump delivering 1200 g.p.m. against a 40-ft. head, direct connected to

1 General Electric Co. Type D-54, 30-hp., 2000-r.p.m., 225-lb. non-condensing turbine.

1 C. H. Wheeler Mfg. Co. 3-in., 2000-r.p.m. condenser circulating water pump to deliver 275 g.p.m. against a total head of 55 ft. This pump is direct connected to

1 General Electric Co. Form D-52, 2000-r.p.m., 8-hp., 225-lb. non-condensing steam turbine which also drives through the 3-in. pump shaft.

1 C. H. Wheeler Mfg. Co. 1½-in. centrifugal hotwell pump to deliver 15 g.p.m. against a total head of 55 ft.

1 C. H. Wheeler Mfg. Co. 1½-in., 2400-r.p.m. centrifugal hotwell pump built to deliver 30 g.p.m. against a total head of 55 ft.

1 General Electric Type D-52, 7.5-hp., 2400 r.p.m., 225-lb. non-condensing turbine.

1 C. H. Wheeler 2-in. centrifugal hotwell pump designed to deliver 50 g.p.m. against a 55-ft. head. Direct connected to

1 General Electric Type D-52, 5-hp., 2400-r.p.m., 225-lb. non-condensing steam turbine.

2 American Steam Pump Co. Style HM, 3½-in., 400-g.p.m., 158-ft. head, 1750-r.p.m. centrifugal cold water service pump direct connected to

2 Fairbanks, Morse & Co. Type B, 30-hp., 1800-r.p.m., 440-v., 3-ph., 60-cycle induction motors.

1 American Steam Pump Co. Style HM, 2½-in., 150-g.p.m., 150-ft. head, 2200-r.p.m. centrifugal cold water service pump direct connected to Kerr turbine.

connection for service water in an emergency. The small condenser under the compressor is of the two-pass type with a single stage Radojet handling 7.35 cu. ft. of free dry air at 25 in. vacuum. This unit is supplied with 275 g.p.m. of circulating water and condenses a maximum of 2900 lb. of steam per hour.

Circulating water for all of the units is cooled in a

Both generators are cooled by an open system with air supplied by an 11,000-cu. ft. per min. Clarage fan and air washer. In addition each turbine has an individual oil cooler cooled by service water. Oil is purified periodically in a centrifugal oil purifying unit installed for that purpose.

Power house auxiliaries are all steam driven but

both motor and steam driven service pumps are used to serve the factory system. All the pumps used are of the centrifugal type, the majority being single stage. Both the photograph, Fig. 8A, and the plan, Fig. 9, show the arrangement of the service pumps which, on the latter, are designated by numbers 5 to 10 inclusive. Numbers 5, 7, and 9 are cold water service pumps. Number 5, turbine driven with a capacity of 150 g. p. m., the remaining two motor driven with a capacity of 400 g.p.m. each.

Number 10 is a motor driven hot water circulating pump is placed in close proximity to the 4 ft. 6 in. by 16-ft. hot water heater located in the boiler room basement, adjacent to the partition. Water in this tank is maintained at 180 deg. F. by a thermostatic control, low pressure steam for the purpose being taken from the exhaust header leading to the water softener heater.

Drinking water is supplied by pumps Numbers 6 and 8, the first turbine driven, the second motor driven. All auxiliary turbines are designed to use full pressure superheated steam at 225 lb. gage, 100 deg. superheat. Motors are all 440-v., 3-phase, 60-cycle, induction mo-

Principal Power Plant Equipment at National Lock Company (Cont'd)

1 Kerr Turbine Co. 15-hp., 3 B split case, 225-lb., 100-deg. superheat, non-condensing turbine.
2 Fairbanks, Morse & Co. 2-stage, Fig. 1052NT centrifugal drinking water pumps. One is direct connected to
1 Terry Steam Turbine Co. 15-hp., 2200 r.p.m., 225-lb. non-condensing turbine, the other direct connected to
1 Fairbanks, Morse & Co. Type H, 15-hp., 1800-r.p.m., 440-v., 3-ph., 60-cycle motor.
1 American Steam Pump Co. Type HM, 2-in., single-stage, 100-g.p.m., 20 ft. head centrifugal hot water circulating system direct connected to
1 Fairbanks, Morse & Co. Type B, 1½-hp., 440-v., 3-ph., 60-cycle motor.
2 Fairbanks, Morse & Co. vertical float controlled sump pump driven by
2 Fairbanks, Morse & Co. vertical 3-hp., 1750-r.p.m., 440-v., 3-ph., 60-cycle motors.
1 Economy Pumping Mach. Co. 1½-in., single-stage, single-suction air washer circulating water pump, rated at 85 g.p.m. against 50-ft. head. Driven at 1800 r.p.m. by
1 Fairbanks, Morse & Co. Type H, 3-hp., 440-v., 3-ph., 60-cycle induction motor.
1 American Steam Pump Co. 1½-in., Type HM, single-stage water treater pump. Designed to deliver 60 g.p.m. against 50-ft. head at 1750 r.p.m., driven by
1 General Electric Type KT, 3-hp., 440-v., 3-ph., 60-cycle, 1800-r.p.m. induction motor.
1 American Steam Pump Co. 3-in., Type HM, single-stage water treater pump delivering 295 g.p.m. against a 20-ft. head driven by
1 General Electric Type KT, 5-hp., 1800-r.p.m., 440-v., 3-ph., 60-cycle induction motor.

Boiler Room Equipment

3 Connelly Boiler Co. Class SS 18, 412-hp. water tube boilers with a total heating surface of 4120 sq. ft. Built to generate steam at 225 lb. 100 deg. superheat, with a maximum rating of 175 per cent. Equipped with
3 Superheater Co. Elesco, 265-sq. ft. superheaters made up of 24—1½ in., No. 9 B. W. G. elements. Designed to give 100 deg. superheat at 225 lb. pressure and 175 per cent rating.
3 Combustion Engineering Co., Green chain grate stokers driven by
2 E. H. Wachs stoker engines.
3 Power Specialty Co. 6-element Diamond soot blower units.
6 Crane Co. 2½-in. safety valves.
3 Manning, Maxwell & Moore, Inc., 2½-in Consolidated safety valves.
3 Reliance Gauge Column Co. safety water columns
6 Yarnall-Waring Co. blowoff valves and cocks.
6 Allen-Sherman-Hoff Co. Type C water collecting ash gates. Two 3 by 4-ft. gates per boiler operated by one common 6½-in. diam. steam cylinder.
3 Allen-Sherman-Hoff Co. cast-iron ash hoppers with gravity lock tile construction.
1 Allen-Sherman-Hoff Co. 30-t., cast-iron outside ash hopper with 22-ft. bottom clearance.
1 Link-Belt Co. floor-operated, motor-controlled, 1000-lb. weigh larry, driven by a 2-hp., 1160-r.p.m. motor. Speed in either direction 120 ft. per min.
1 Link-Belt Co. 16 by 15-in. gravity discharge elevator-conveyor, driven through a silent chain by a 16-hp., 860-r.p.m. motor. Centers placed 64 ft. vertical and 80 ft. horizontal. Bucket speed 100 ft. per min. Upper run troughing arranged to discharge at 8 points through rack and pinion slide gates operated from the walkway.
1 Link-Belt Co. 30-in. by 17 ft. apron feeder with a speed of 5 ft. per min. and driven by a 5-hp., 1200-r.p.m. motor.
1 Link-Belt Co. 26 by 24-in. double roll coal crusher with a 66 by 8-in. flywheel pulley belted to a 15-hp., 860-r.p.m. motor.
1 Carrick Engineering Co. combustion control system.
6 General Electric Co. electric flow meters, 3 indicating and 3 recording.
1 The Hays Corp. multiple draft gage.
3 Bacharach Industrial Instrument Co. Siemens & Halse CO_2 indicators and recorders.
1 Hayden-Derby Mfg. Co. Metropolitan injector.

Water Heaters and Treater

1 Milwaukee Reliance Boiler Wks. Class F, 4000-hp. open induction type feed water heater.
1 Blackburn-Smith Corp. twin filter.
1 International Filter Co. Style H-6 hot flow water softener with a capacity of 2500 gal. per hr.
1 Powers Regulator Co. thermostatic temperature control on hot water heater.

Miscellaneous

1 Ingersoll-Rand Co. Imperial Type 10, 10 and 25 by 14 and 22 by 16-in., 200-r.p.m., 80-lb. cross compound air compressor with inter and after cooler.
1 Kewanee Boiler Co. 16 by 3-ft. diam. air receiver.
1 Clarage Fan Co. Type V, Size 5-9, 11,000-cu. ft. air washer.
1 De Laval Separator Co. No. 200 centrifugal oil purifier.
5 Ruggles-Klingemann Mfg. Co. R. K. regulators for controlling air and steam pressures.
2 Ruggles-Klingemann Mfg. Co. bleeder check valves, 12 and 14 in.
2 Illinois Engineering Co. Eclipse atmospheric relief valves.
1 Whiting Corp. 30-t. crane.
Chimney built by Weber Chimney Co.
Piping by Grinnell Co.
Engineering and Contractors, Swords Bros.
Valves and checks, Jenkins Bros.
Boiler setting, Chicago Fire Brick Co.

tors, with the exception of the small oil purifier drive which is 110-v. single phase.

Chief Engineer's Office Is Located on Turbine Room Gallery

The building itself is of steel and brick construction, the sawtooth top of the turbine room assisting greatly in the natural lighting. Practically 85 per cent of the wall area is window space giving excellent ventilation and providing abundant light in every part. A Whiting, 30-t. crane serves the turbine room, while a 25-ft. gallery, reached by a spiral staircase, extends across the width of the building. One corner of this gallery is glassed in as an office for chief engineer Harry W. Devenney. This office, shown in Fig. 3, has an unobstructed view of the turbine room and turbine operating gage boards. Each boiler has a flow meter and CO_2 meter and the recorders of these instruments are mounted above the engineer's desk in the office.

The plant, as a whole, is a striking example of modern industrial power plant development, utilizing extraction type turbines, feed water heating, and both motor and turbine driven auxiliaries. Although it has been in service but a few weeks, operating expectations have been met even on the light electric load which is being carried. This perhaps is due more to the careful supervision and attention to detail on the part of the engineer at present, but as the load is built up and the load factor increases, design features will have a relatively more important bearing on the overall efficiency and the operating record of the coming year should give important data on the advantages of extraction type turbines in industrial plants.

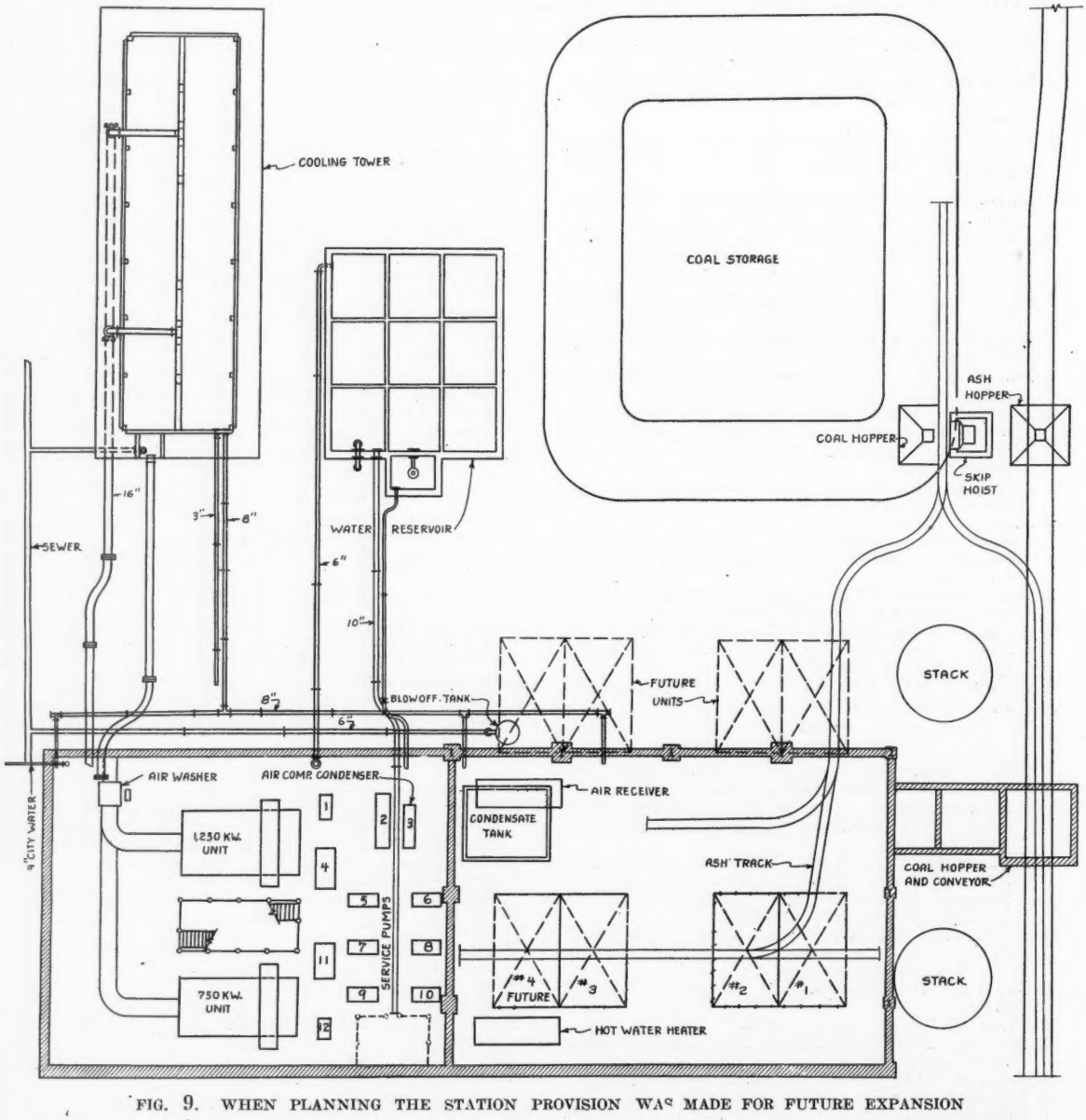


FIG. 9. WHEN PLANNING THE STATION PROVISION WAS MADE FOR FUTURE EXPANSION

Power Plant Equipment Number

INDUSTRIAL PROGRESS is a curious combination of startling innovations, recurring cycles of progressive application and finally refinement of details to meet definite conditions. Changes are inevitable, largely the result of economic pressure brought to bear upon those directly responsible for production.

Power plants are no exception, but because they are the one common link of all industries, have been subjected to a combined pressure which has resulted in progress unequaled in any other line. The broadness of the field, the many angles of attack, the fact that hundreds were striving for the same result, each from a different starting point, meant little until after the realization that organization of community of interest was necessary to keep each one informed of the progress and difficulties of the others so as to avoid duplication.

In our field the greatest progress has taken place within the last 20 yr. Men still active in power production have seen large, cumbersome reciprocating units give way to compact turbine units and these units in turn give way to other turbines as massive as the original engines but producing 50 times as much power.

Co-ordinated Effort of Science and Industry Produces Results

But, although trends such as these are well defined and easily traced, one cannot, with veracity, say that any one thing or development is responsible. True, the turbine helped but, without the co-operation of metallurgists to produce metals which would withstand high pressures and temperatures, electricians to produce high voltage, high speed machines and long-distance transmission equipment and engineers to produce high vacuum condensing equipment, it is likely that we would today be reading with astonishment of the new 20,000-kw. uniflow being built for the new 50-mi. super power system, instead of the new 200,000-kw. turbine unit which will take its place in a system already extending half way across the continent.

Cause and effect are indeterminate in most cases. It would be impossible properly to classify pulverized coal, water wall, high boiler rating, evaporator, deaerator, air preheater and condenser development without tying each development up closely with the others. Pulverized coal was, perhaps, the spark which started the motion but, without the development along other lines, the flare would have burned out, as it had done in previous years. That the same developments could have been adapted to stokers earlier is evident by the progress that has been made in this line since pulverized coal pointed the way.

Manufacturers Responsible for Detailed Solutions of Problems

Certain lines are developed and brought to the front through efforts of the manufacturers, while others, particularly refinements, are brought about as a definite solution of one or more operating problems. In previous issues we have analyzed power plant development and construction, followed certain trends and problems which have been encountered and solved.

Naturally, the solution of these problems, or at least the details of the solution, are put up to the manufacturer. Economic and manufacturing conditions are to be met, sometimes making it difficult for an operating man or outsider to understand the manufacturer's point of view.

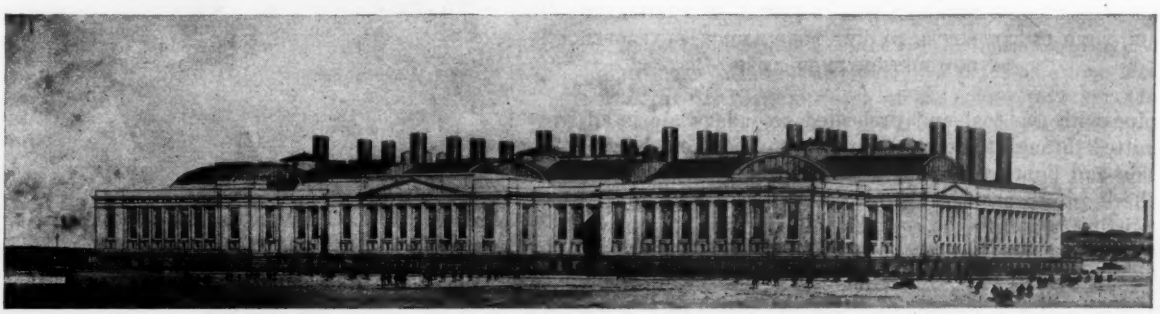
For this reason we believed it advisable to let these manufacturers cover the developments of their own particular equipment and present in their own words, their practical solution of the difficulties and problems encountered by the power plant industry as a whole.

Steady Advance Makes Attainment of Perfect Performance Less Remote

Recent progress has been devoid of startling developments. It has been the steady advance toward perfection rather than a few master strokes of genius—a thorough understanding of requirements and problems, full co-operation between manufacturer and operator and, lastly, the competition of manufacturers to find solutions of the various problems.

The steady advance of furnace and boiler efficiency up to and beyond 90 per cent, of electrical generating and transmitting equipment to 95 and 98 per cent and Rankine cycle turbine ratios past 75 per cent has been through effort. Feed-water heating and treating, condenser design and construction, deaeration and evaporation all have their influence on the station as a whole.

Each problem is separate, yet tied up with many others; definite, yet its solution is incumbered by limitations and we believe that the only way to record true progress in our field is to view it from every side. Accordingly, with the co-operation of manufacturers, we have prepared this issue to cover development from an angle which can be reached in no other way.



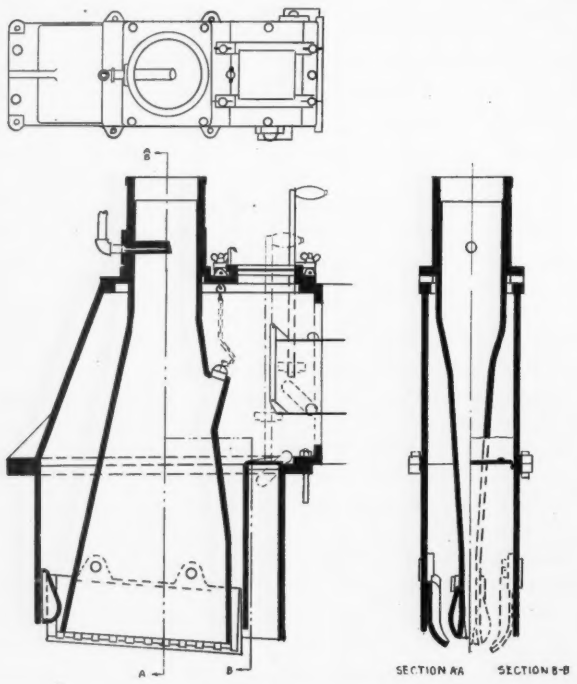
COMBUSTION EQUIPMENT

Pulverized Coal Equipment Shows Steady Progress

STATEMENT BY THE COMBUSTION ENGINEERING CORP.

INCREASE IN THE NUMBER of stations which have selected pulverized fuel for steam generating is an indication of the trend in boiler room practice. The central preparation plant or storage system is the leader in this field, especially for large stations, but lately considerable interest has been shown in the application of the unit system for plants of smaller capacity.

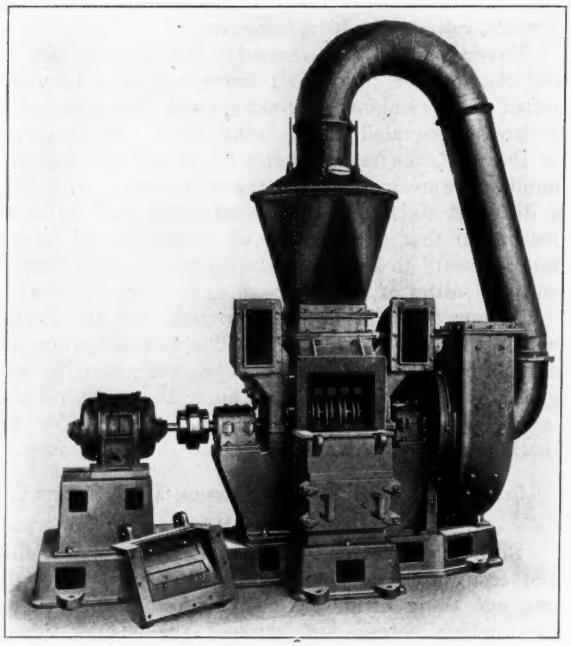
Extensive use is now being made of preheated air in the pulverized coal burners. This illustration indicates the latest design of this type of burner in which preheated primary air is admitted through the inner



LOPULCO BURNER DESIGNED FOR ADMISSION OF PREHEATED AIR, WITH CHEEK PIECES TO GIVE TURBULENCE, DEVELOPED BY COMBUSTION ENGR. CORP.

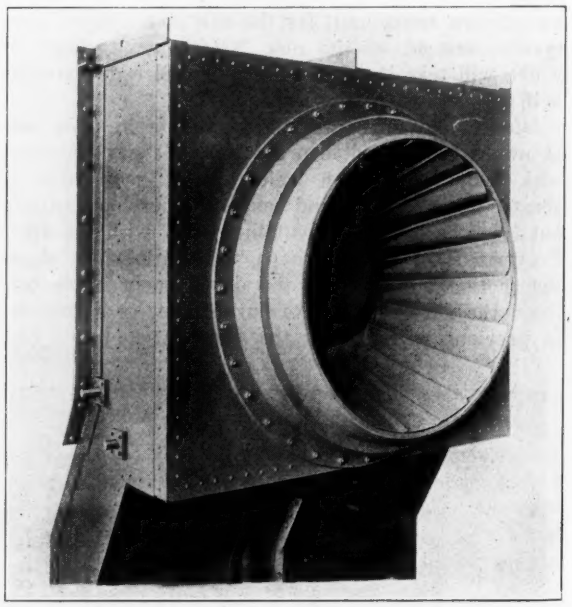
pipe with the coal and preheated secondary air is admitted through the outer casing. Provision for observation and lighting is made at the top of the burner and cheek pieces are located at the burner tip to give a twisting action to the coal and air mixture as it leaves the burner.

The C. E. unit system shown consists of Raymond impact mill and burners of either the Couch or Lopulco



ONE OF THE LARGER IMP MILLS OF COMBUSTION ENGR. CORP. WITH INTEGRAL FAN AND CLASSIFIER

type. The smaller sizes of mills have the feeder, mill and fan combined in a single unit, while in the larger



COUCH HORIZONTAL ROTARY BURNER OF COMBUSTION ENGR. CORP. IS DESIGNED TO PRODUCE TURBULENCE OF COAL AND AIR MIXTURE

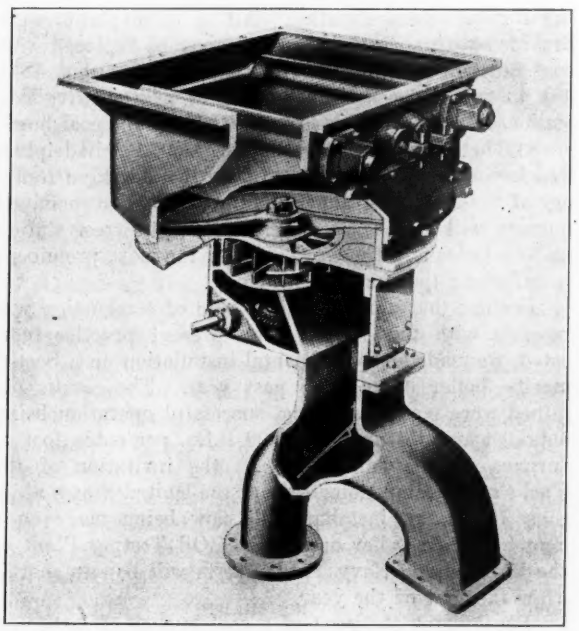
sizes the feeder and fan may be separate from the mill and located at a different elevation. The photograph shows one of the larger sizes of Imp mills equipped with integral fan and classifier. Part of the casing is removed to show the hammers. The Couch horizontal rotary burner shown operates with a small amount of excess air and the turbulence created in the mixture of coal and air as it enters the furnace results in shorter flame travel which makes its application very satisfactory to furnaces of restricted volume.

Statement by Erie City Iron Works

Our Unitype pulverizer has been redesigned to a paddle-type, three-stage machine. It has been equipped with Timken tapered roller bearings. The design and assembly of the liners and diaphragms has been simplified. The bearing blocks have been cast integral with the housing, which has shortened the shaft and made the whole machine more sturdy. Increased speed has largely increased the capacity of our various machines and the whole line has been thoroughly standardized.

Statement by Fuller-Lehigh Co.

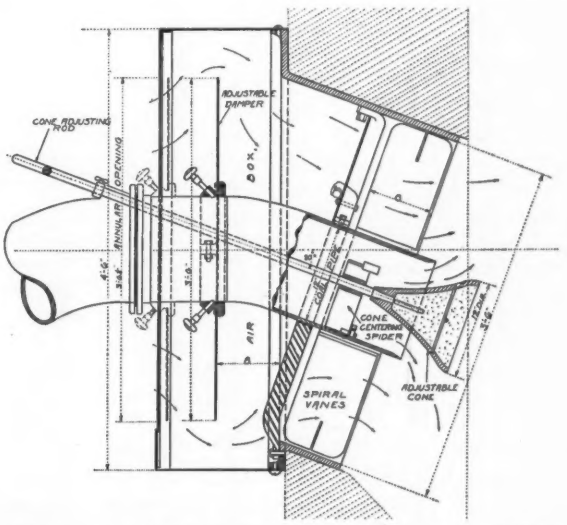
Among the important developments of the year is that of the Bailey feeder and meter for pulverized coal designed primarily to deliver and measure pulverized coal from storage bins to burners. It has been constructed to prevent arching of coal above the feeders and at the same time to prevent flooding through the feeder which causes irregular combustion in the furnace. In developing this feeder, consideration was given to the problem of feeding the coal from a metering standpoint with the result that the feeder can be used to give accurate and reliable data concerning fuel consumption, one installation having reported that the check between the feeder speed and the weighed coal agrees within 2 per cent.



BAILEY PULVERIZED COAL FEEDER AND METER SHOWING DISTRIBUTOR, FLUFFER WHEEL AND FEEDER, MADE BY FULLER-LEHIGH CO.

The feeder consists of a hopper with shutoff gates, as shown in the illustration, the upper flange of which is bolted to the pulverized coal bin. This hopper provides a large unobstructed opening between bin and feeder. The gates when open form a passageway 20⅜ in. wide and 27½ in. long. A rotating distributor directly below the gates undercuts the coal in the hopper and prevents bridging, also insuring a constant and steady supply of fuel from all parts of the bin opening. From the hopper the coal feeds through the feeding and metering mechanism to the coal and air mixer where the primary air picks it up and carries it to the burners. The design is such that the feeder will give a uniform and dependable rate of coal feed over a speed variation of from 10 to 1.

This feeder is made in capacities of 4000, 6000, 8000 and 10,000 lb. an hour, having the same hopper and overall dimensions in each case. A special Y-shaped discharge opening can be supplied for operating two burners from one feeder. Tests have shown less than



SECTION OF BAILEY-TENNEY PULVERIZED COAL BURNER SUPPLIED BY FULLER-LEHIGH CO.

0.90 hp. required when operating at over 4000 lb. of coal an hour.

The Bailey-Tenney pulverized coal burner has been designed for horizontal firing and may be used for either natural or forced draft secondary air supply. It is particularly adapted to furnaces having a restricted volume and is used with a solid refractory front wall, through which the burner enters the furnace. It is built in capacities up to 7500 lb. of coal an hour.

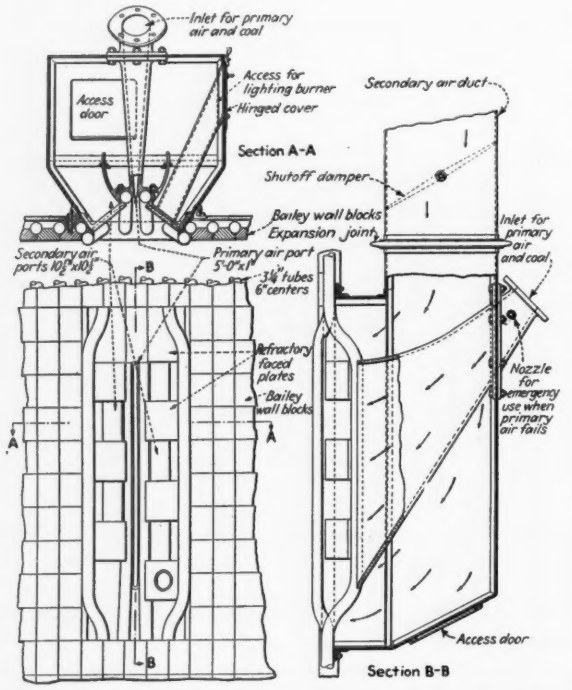
As shown in the illustration, the Bailey-Tenney burner consists of a center pipe or nozzle, through which primary air and coal enter. An adjustable cone inserted in the discharge opening of the center pipe spreads the flame. The secondary air entering through the annular space around the center pipe is swirled by the burner vanes to give a thorough mixture of coal and air. In the Bailey-Tenney burners applied at the Ashley Street Station approximately 50 per cent of the air enters as primary air with the coal, the remainder being drawn in around the burner nozzle by the draft in the furnace.

Designed especially for adaptation to the Bailey fur-

nace wall construction is the Calumet burner shown in the illustration. This is designed to produce extreme turbulence and to cause intense combustion, the coal and air spreading evenly throughout the furnace, utilizing to the fullest extent the advantages of the Bailey wall construction. The amount of primary air may be held to a very low percentage, thus facilitating the use of preheated air for combustion. The primary air nozzle is tightly clamped to the water-cooling tubes so that coking will not occur at the burner tip. The burner is made in capacities up to 8000 lb. of coal an hour.

This Calumet burner injects the primary air carrying the pulverized coal into the furnace through a long, narrow, vertical slot between the water-cooling tubes. Secondary air enters through ports on either side of the primary air jet. These ports are at an angle with the primary air jet and are staggered instead of opposing each other.

The Lehigh pulverizer mill is also a new development of this company. This is of the air separator type but



FULLER-LEHIGH CO. SUPPLIES THE CALUMET TURBULENT BURNER FOR USE WITH BAILEY FURNACE WALLS

can be made in the screen type if required. The mill is available in capacities from 3 to 20 tons an hour and for either the unit or the bin system. It is designed to be especially stable and rigid. A massive base plate serves to take up the shock and pressure of the grinding elements and to support the grinding ring. It also forms a rigid support, from which the spiral bevel gear and pinion housing and bearings are suspended. The top section contains the Y, on which are mounted the pushers for actuating the balls and the fan blades to lift the coal to the separating chamber. The pulverized coal and air mixture is withdrawn from this chamber by the exhauster which delivers it to the burner or cyclone separator. Coal is supplied to the mill by an independent motor-driven feeder. The base plate of this new mill rests directly on the concrete foundation which is recessed to receive the gear housing and the pinion shaft, to which a motor is direct connected through a flexible coupling.

Within the past two years the company has developed or acquired three distinct types of unit mills: first, a high-speed impact type of mill operating at approximately 1200 r.p.m.; second, a low-speed tube mill operating at approximately 30 r.p.m.; third, a medium-speed ball mill operating at approximately 200 r.p.m. Owing to the wide diversity of American coals and of operating conditions, each of these mills should find proper application to specific conditions.

A fourth type of installation which may be termed the "Unit Central System" has been made on three 15,000-sq. ft. boilers at the plant of the Broad River Power Company at Parr Shoals, S. C. This system is designed to combine the advantages of both the unit and central systems and, where properly applied, requires little or no additional building capacity over that of the usual unit system. In this installation all necessary equipment is contained in the boiler house itself. Mills are located on the basement floor, between ash hoppers and at the ends of the buildings, while raw or pulverized coal storage bins and other necessary equipment are located above the operating floor between the boilers.

Statement by Peabody Engineering Corp.

In August, 1925, we installed three combined coal and oil burners under one of the Springfield boilers at the Sherman Creek station of the United Electric Light & Power Co. This installation was such a marked success that the Phoenix Utility Co. purchased these burners for use on oil at their stations at Ft. Lauderdale and Sanford, Florida, and the W. S. Barstow Management Association, Inc., installed them under boilers at the Benson Springs station. All of these plants were provided with spacer rings which may be replaced with coal burners at a later date. Stone & Webster, Inc., has installed the combined burners at the Riverside station of the Savannah Electric Co. and the coal burners at The Franklin Sugar Refining Co. in Philadelphia, and has ordered this equipment for the Brooklyn Refinery of the American Sugar Refining Co. The combined burners will also be used at the Market Street station in New Orleans. These are some of the more prominent installations that have been made.

Feeling that a much higher rate of combustion was possible with this burner than present practice indicated, we made an experimental installation on a Scotch marine boiler during the past year. The results obtained were most gratifying, successful operation being obtained at rates up to 100,000 B.t.u. per cubic foot of furnace volume per hour. At the invitation of the Fuel Conservation Committee of the United States Shipping Board, an installation is now being made on a Scotch marine boiler at the Fuel Oil Testing Plant in the Philadelphia Navy Yard. Tests will be run shortly after the first of the year.

Recognizing the need of a coal burner of larger capacity with lower draft drop, this company designed a coal burner which has been tried experimentally and which will operate at rates of 5000 lb. of coal per burner

and upwards. A complete installation is being made at the present time and operating results will be obtained in the first part of the year.

STATEMENT BY POWER SPECIALTY CO.

One striking feature in the expansion of pulverized coal firing has been the frequent selection of the unit system for power plant service during the past year. A number of plants have extended their installations of Aero pulverizers on the basis of past performance. The fact that the original Aero system combined in one machine the preparation of fuel and its delivery to the furnace with air for combustion has resulted in years of experience along lines now accepted as standard.

At the heating plant of the Lockport Light, Heat & Power Co., Lockport, N. Y., the size "E" Aero pulverizer of 3000 lb. per hour capacity was put in operation firing a 402-hp. Stirling boiler in December, 1924, and has since been in practically continuous service. The construction of the furnace is of solid refractories throughout with the exception of the floor, which is air-cooled. With average boiler ratings of slightly over 200 per cent and peaks of 300 per cent, the ash is deposited in granular form and is very easily removed. The monthly efficiencies are from 80 per cent to 82 per cent for boiler and furnace and it is interesting to note that no shut-down has ever been caused in this plant by the pulverized coal equipment. On the basis of this experience, the Lockport Co. is now erecting a new 750-hp. Stirling boiler unit to be fired by a size "G" Aero pulverizer.

At the Elmira Water, Light & Railway Co., at Elmira, N. Y., the size "G-4" Aero pulverizer of 8000 lb. per hour capacity was installed in connection with a 768-hp. B.&W. boiler and an air-cooled furnace in the fall of 1925. With normal operation at about 200 per cent rating, the monthly overall efficiency of boiler and economizer varies from 82 per cent to 85 per cent and CO_2 readings from 14 per cent to 15 per cent. Seven tests for fineness of pulverization at this plant showed from 93 per cent to 99 per cent through 100 mesh and from 76 per cent to 90 per cent through a 200-mesh sieve. A second Aero pulverized coal unit is now in course of erection, connected to a 768-hp. boiler arranged with Foster water wall furnace.

Early in 1925, two size "D" Aero pulverizers were put in operation at the Standard Steel Car Co.'s plant at Hammond, Ind., firing two 250-hp. B.&W. boilers, as shown in Fig. 3. Each pulverizer has a capacity of one ton of coal per hour, and the boilers are normally operated with coal containing 13 per cent of moisture and 17 per cent of ash, at from 150 per cent to 200 per cent of rating. The monthly efficiencies show approximately 77 per cent. The operation of these pulverized coal-fired boilers proved so entirely suited to their conditions that in April, 1926, the Standard Steel Car Co. purchased two more Aero pulverizers, followed in May, 1926, with an order for four more, which are now being installed and which will complete this plant.

The pulverizer installation of The American Metal Co., Ltd., at Mapimi, Mexico, is of particular interest because of the unusual mounting of the Aero units on trucks. Either electric or steam power is used for driving the pulverizers.

At the St. Joseph Gas Company, St. Joseph, Mo., the Aero pulverizer installed in 1925 and shown in Fig. 5, has successfully fired a 306-hp. Heine "V" type boiler with lignite and petroleum coke, as well as Illinois and Missouri coals. Under usual conditions, the 3000 lb. per hour Aero is operated to produce from 150 per cent to 175 per cent of rating on the boiler. Under test, using Sandow lignite containing 34.8 per cent moisture, 14 per cent ash and 7123 B.t.u., the Aero maintained a rating of 170 per cent with a CO_2 of over 14 per cent. Recently tests have been made firing petroleum coke of the following analysis:

Moisture	10.94 per cent
Volatile	16.51 per cent
Fixed Carbon	72.06 per cent
Ash	1.39 per cent

with extremely satisfactory results. Ratings of 135 per cent to 200 per cent were carried with a CO_2 of 15 per cent and over. For test purposes, water was poured directly into the fuel hopper until the coke was washed into the pulverizer. Neither the rating nor the steam pressure was materially affected thereby.

STATEMENT BY RILEY STOKER CORP.

Quite a number of improvements have been made to the Atrita Unit Pulverizer during the past year. A special construction of hammer head is now used in the preliminary pulverizing chamber. In the second effect, or fine pulverizing chamber, instead of using two rows of small stationary and two rows of small revolving pegs, we are now using one row of large 2½-in. diameter round moving pegs and stationary pegs. This has more than doubled the life of this part of the pulverizer and as the pegs wear the fineness of pulverization actually slightly increases. The rotor is equipped with a hard steel liner so as to reduce the maintenance of this part.

The fan construction has been changed from that of a regular steel plate fan. The new fan consists of a rotor upon which are bolted the fan blades. This makes the renewal of worn fan blades a simple matter and of course lowers the maintenance of this part of the pulverizer.

Progress in Stoker Design

STATEMENT BY AMERICAN ENGINEERING CO.

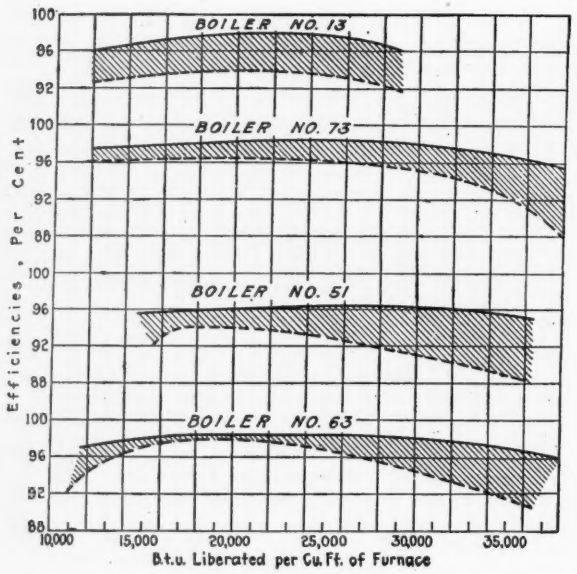
IN THE field of underfeed stokers the tendency is continually toward larger units and higher capacities, this company being prepared to build stokers which will give 450 per cent of boiler rating continuously and 700 per cent on peaks with boilers now being built.

Briefly summarized, the outstanding developments of the year include:

(a) Increasing trend toward long stokers (41 tuyeres and up) for firing large boilers.

(b) Continued development of the stoker for use with preheated air, which has made it possible materially to reduce furnace volumes.

(c) New high marks in stoker efficiency and boiler output are being revealed by operating data in the new modern stations such as Hell Gate, Kearny, Edgar and Richmond, which are now on an operating basis.



FURNACE EFFICIENCIES OBTAINED AT HELL GATE STATION WITH TAYLOR STOKERS

(d) Adoption of stokers for firing the largest boilers in the world at Beacon Street central heating plant of the Detroit Edison.

(e) Maintenance costs on stoker parts are being rapidly reduced by the adoption of new principles of design.

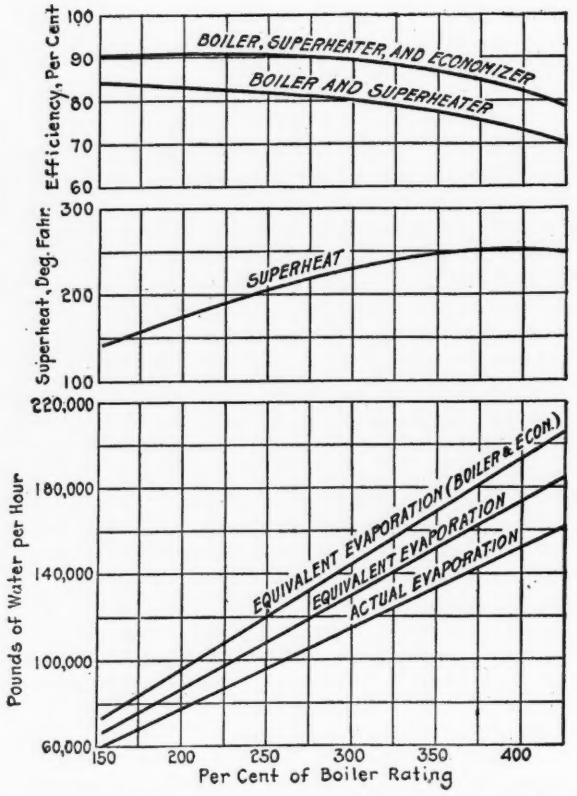
The new Picway Station of the Columbus Railway, Light and Power Co. and the new Norfolk Station of the Virginia Electric and Power Co. are recent examples of the installation of long stokers. Installations of stokers for burning as much as 2200 lb. of coal per hour per front foot of boiler are now under consideration and this company is prepared to supply stokers of even greater capacity.

High capacity long stokers remove all limitations on boiler size so far as the stoker is concerned. They accomplish a more complete burning out of the carbon in the fuel and increase the area of the radiant surface for direct heat transfer to the boiler.

In service, long stokers have proved extremely satisfactory with high efficiency in daily operation. A type has been developed which gives complete control of the fuel bed at all points to conform to the requirements of different kinds of coal.

At the Providence meeting of the American Society of Mechanical Engineers last May, H. W. Leitch, general superintendent of power plants of the United Electric Light and Power Co., presented curves, reproduced here, of test results with later stoker installations at Hell Gate Station which showed furnace efficiencies (based on saturated steam temperatures) ranging above 96 per cent for various rates of heat liberation up to 30,000 B.t.u. per cu. ft. of furnace volume.

Mr. Leitch's analysis of tests with this Taylor-stokered boiler revealed overall efficiencies (furnace, boiler, superheater and economizer) ranging up to 94 per cent, and not dropping below 80 per cent until the boiler was forced above 400 per cent of rating, as shown in the test results on boiler No. 73.

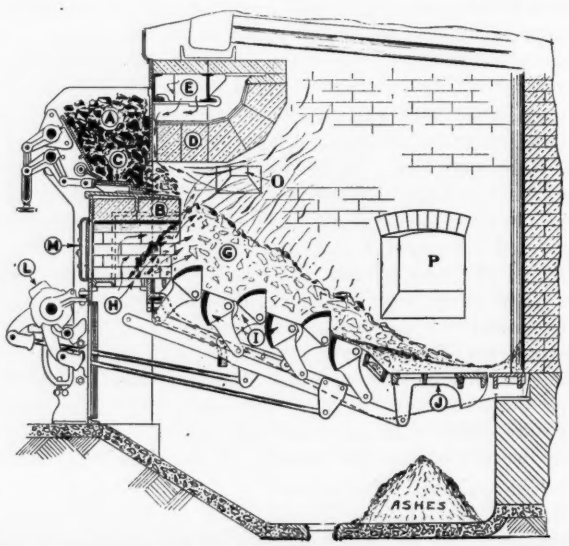


RESULTS OF TESTS ON BOILER NO. 73 SERVED BY TAYLOR STOKER AT HELL GATE STATION

STATEMENT BY MARION MACHINE FOUNDRY & SUPPLY CO.

The Marion Type "K" inclined grate stoker is the latest development by the Marion Machine, Foundry & Supply Co. The grate surface is inclined with rocking grates to feed the coal down the grate surface and a dump grate at the back to drop the ash and clinkers.

Coal is fed in small quantities onto a hearth above



SECTION THROUGH THE MARION TYPE K INCLINED GRATE STOKER

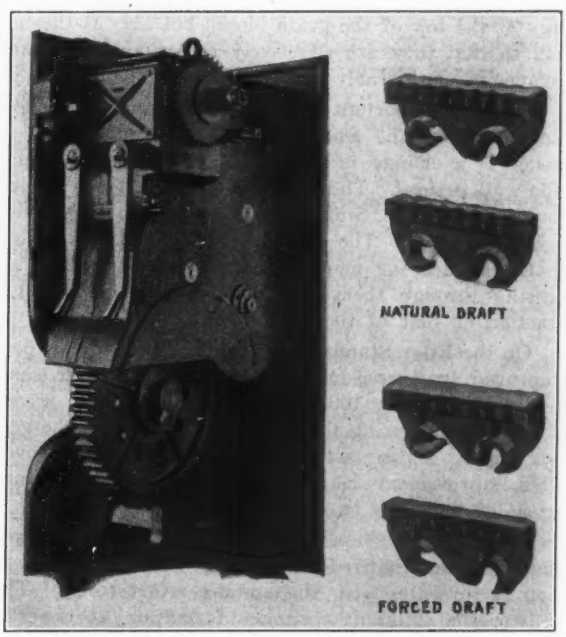
the grates, where it starts to burn and is then pushed off on to the front of the grate surface. The feed is adjusted to the coal and load. The whole is operated by a steam or water motor. The front is made tight, so forced draft may be used if desired. It will burn about 50 lb. of coal per sq. ft. of grate surface per hour with forced draft and about 25 lb. per sq. ft. with good natural draft.

Furnace volume should be about 25 cu. in. per 1000 B.t.u. burned per hour. This will be a reasonably high setting and with proper mixing arches will give good results with nearly all coals.

Good natural draft with proper damper control will ordinarily take care of a reasonable overload and with forced draft a much greater overload can be carried.

Fuel feed control is regulated by adjusting the stroke of the pushers for the grade of coal burned and by the motor speed for the load. The stoking control is such that the movement of the bars is comparatively fast so that they are not exposed in the fuel bed for more than a few seconds. The period between stoking is long enough to burn the coal added to the furnace during that time.

Part of the fine ash sifts through the grates during the stoking. The rest of the ash and clinker is moved on down to the dump plate and can be dumped as necessary.



MC CLAVE SPIRAL GEAR DRIVING MECHANISM FOR LARGE UNITS

MC CLAVE REPLACEABLE REGULAR AND SPROCKET LINKS FOR NATURAL AND FORCED DRAFT OPERATION

Statement by McClave-Brooks Co.

During the past year we have placed on the market our new forced draft chain grate stoker and natural draft chain grate stoker for bituminous fuel, as well as our forced draft chain grate stoker for anthracite fuel. One of the principal parts of our chain grate stoker, which we have improved, is the spur gear drive, which completely eliminates worm reductions either at the front or the rear of the stoker, this drive being used with both the anthracite and bituminous stokers.

This spur gear drive is designed especially for continuous operation and consists essentially of a train of gears directly connected with one another at all times. Three different speeds are regulated by two hand levers located on the front side of the gear house. These levers shift a spiral clutch on the main drive shaft in contact with the clutches on the gear. This prevents stripping of the gear teeth. A special locking device allows only one speed change at a time. Markings are placed on the gear housing which indicate the direction in which the speed changing levers are to be shifted and thus automatically lock in their respective positions. On the outer end of the main driving shaft is provided a safety tension spring attachment as a protective measure for any part of the stoker while in operation. Any sudden stopping of the stoker due to some unknown cause or excessive strain in any part will react on the tension spring allowing the driving sprocket wheel to turn without moving the stoker.

Another important development has been the replaceable link, wherein every link is replaceable so that repairs can be made without interfering with the load on the boiler.

The chain grate is composed entirely of removable links instead of the usual solid links; both the regular and sprocket links are of the removal type. Replacements can be quickly accomplished by applying a jack while the stoker is in operation, if necessary, thus eliminating the expense of using special replacement links and reducing maintenance to a minimum.

At the present time this company is developing a new single retort underfeed stoker which will be ready for the market by February 1.

Statement by Riley Stoker Corporation

Probably one of the biggest improvements which has been made in the Riley stoker in the last four or five years is the change which we have just incorporated in the grate construction. The grate blocks instead of being placed immediately on the moving retort sides are placed on a space which is located on the retort sides. This space is so constructed as to permit the installation of two live grids, one blank and one live grid, or two blank grids. It is apparent that by adjusting the use of live and blank grids air can be admitted to that part of the stoker which will give the best combustion conditions for the particular type of coal that is being burned.

This type of construction was developed primarily for use with preheated air and the use of the grids increases the tuyere area of the stoker about 50 per cent. This construction has had a surprising effect on the capacity and the efficiency of the stoker and construction conditions are so improved that the fire is handled far easier. Higher CO_2 is obtained and combustible in the ash is decreased. This type of construction is applicable to our older installations by merely replacing the old style grate blocks with the newer type. The new design of grate surface is such that air is admitted not

only at the top of the grate blocks but also at the bottom so that they are effectively cooled and the maintenance is considerably less than that of the older type.

Another important improvement which has been made in both the Standard and the Super type of stoker is a change in the design of the moving high side wall tuyeres. These tuyeres are now made in narrow sections 2 in. wide instead of in the big section previously used. The design of these sections is such that they are far more effectively cooled by the air passing through them and the maintenance is but a fraction of that of the older type.

On the Riley Standard stoker, the gear box has been improved by increasing the area of the power shaft bearing practically 100 per cent. This has been accomplished by increasing the size of the bearing in the gear box and by adding a third bearing in the front cover. This improvement has materially lessened the maintenance of the Riley two-speed gear box.

On the Riley Super stoker, the overfeed grate section has been changed so that the entire overfeed section reciprocates with the moving retort sides. This construction minimizes clinker formation at the rear of the stoker and assures positive progress of refuse to the rear of it.

Two new types of rear crusher aprons have been developed with the clinker grinder Super stoker. The crusher apron is that part of the stoker forming the upper part of the clinker grinder pit. The Riley Stoker Corporation is fortunate in the use of reciprocating retort sides as it affords a means of imparting movement to the crusher apron, preventing the bridging of clinker formation across the grinder pit. The new construction divides the wall forming the grinder pit on the stoker side into three sections instead of into two sections as formerly used. This not only has the effect of reducing maintenance but it also greatly increases the agitation at this part of the stoker.

In addition to this type of crusher apron we are also manufacturing what we designate as a "kicker apron." This construction gives even greater agitation to this part of the stoker and has been designed for use with bad clinkering coals.

During the past year we have also designed special rocker drum construction for use with the Super stoker. This is similar in design to the rocker dump used in our Standard stoker. The construction, however, is much heavier. Air-admitting blocks are assembled on a heavy cast-iron base. The same crushing action is obtained as with the rocker dump construction in the Standard stoker.

On the Harrington stoker a new type of gate has been designed. In this construction the gate tile extends so as to protect all of the iron work forming the gate. The gate-lifting mechanism, which was formerly a ratchet mechanism, has been replaced by a worm gear reduction so that the gate can be lifted with but a slight effort.

The construction of the lateral retort type of stoker has been altered so that air in the stoker is proportioned by greater tuyere openings at the center of the stoker lessening towards the dump plates. This change in the tuyere areas in the different parts of the stoker gives far better combustion conditions. The construction of the pusher blocks has also been changed in order to give very even distribution of the coal throughout the entire stoker.

We have also developed a mechanical drive mechanism for operating the lateral retort stoker without the use of steam or compressed air. A regular worm gear reduction equipped with Timken roller bearings is used for operating the main plunger, and the lateral retort pusher blocks are operated by a mechanism which receives its power from an extended crank of the main worm reduction drive.

On our standard and side dump stokers, a new type of mechanical drive has been developed. On a single retort stoker a higher speed is desired than on a multiple retort type of stoker. For this reason we have designed a special drive for the Jones stoker in preference to using the regular drive now in use on Riley stokers. The new mechanical drive is quite similar to

RAMBOX WITH RENEWABLE LINERS FOR WESTINGHOUSE STOKERS

the construction of the Riley gear box and it is equipped with bronze gears and Timken roller bearings.

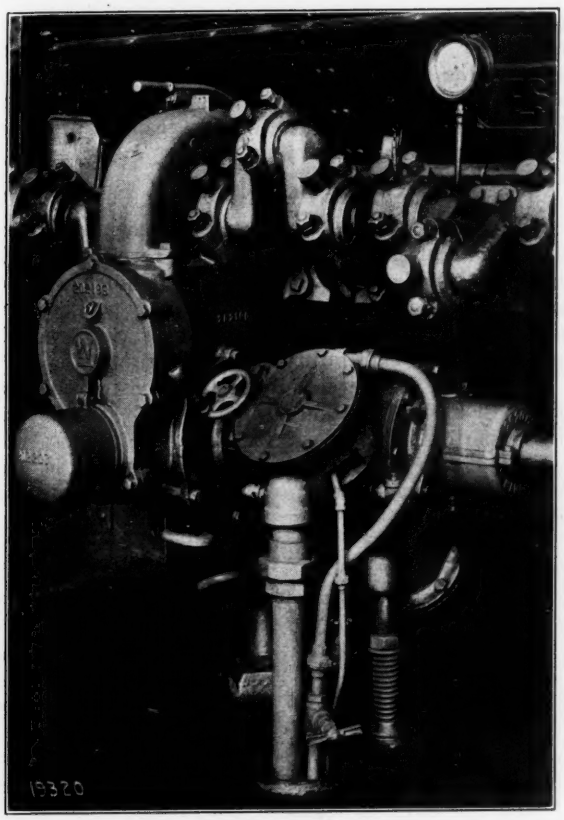
At the rear of this stoker we have developed a plow-shaped plate which directs the refuse towards the side of the stoker rather than permitting it to pile up against the bridge wall causing bridge wall clinker trouble. This construction has been effective in preventing serious bridge wall clinker formation and it has been adopted during the past year by practically all of our users.

Statement by Westinghouse Electric & Manufacturing Co.

Improvements in stoker design have been influenced by the logical demands for higher efficiencies and lower operating costs.

Developments of the multiple retort underfeed stoker as to size have traveled in opposite directions. For the large central station the demands have been for a longer heavier duty stoker and for the progressive large industrial plant the conditions to be met have required a high rating short stoker for comparatively small boilers. The 39-tuyere stoker and the 18-tuyere stoker are representative of these respective developments.

To effect higher efficiencies much has been accomplished by revamping certain parts of the stokers for



STOKER GEAR AND TURBINE DRIVE BUILT INTEGRAL FOR WESTINGHOUSE STOKERS

the utilization of preheated air and for lowering the percentage of combustible in the refuse.

Maintenance has been reduced in several directions. A typical example of developments along these lines is the rambox with renewable liner, illustrated herewith.

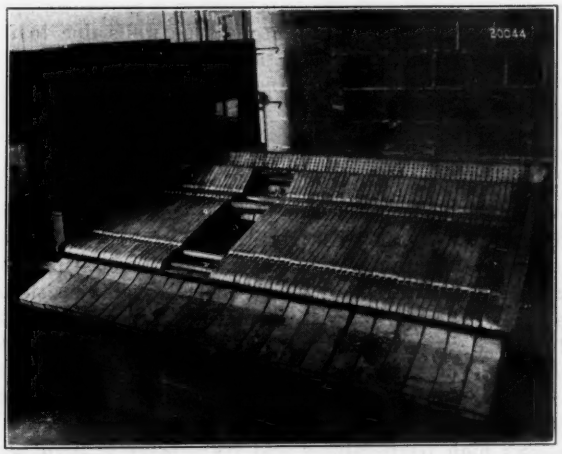
Another selection in multiple retort stoker drive is made possible by the development of the integrally-built turbine, an installation of which is shown in the illustration. This is a compact unit mounted on the two-speed gear box and affords flexibility not usually obtainable with motor drive and occupies much less space than an external engine. It makes an ideal application for wide speed variations where direct current is not available. An indicating boiler rating meter varying as the speed of the turbine forms a desirable adjunct to this equipment.

Single retort underfeed stokers are for boilers up to about 600 hp. and for industrial heating furnaces and have been constantly improved to enable progressive industrial power plant operators to approach the economies of the larger central stations.

Numerous changes in construction have been made during the past year. Combustion at the front of the furnace has been improved by the addition of an air distributing box, as shown in the accompanying illustration, similar in effect to that used on the multiple retort stoker. The design of the grate section has been altered somewhat by changes to the air openings to obtain a more effective air distribution with a lower air consumption and lower static pressure. The internal grate drive has been made more positive and more sturdy by the use of a continuous driving socket as compared to a few separated driving arms.

Improved provision for expansion of the grates without increase of air openings and without any binding of the parts has been accomplished by using a weighted steel cable connected to a deeply recessed compensator casting.

No changes in the Roney overfeed stoker have been found necessary to comply with the conditions for which it is furnished.



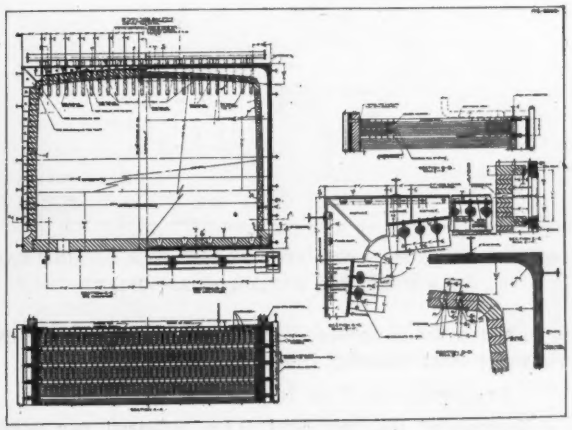
WESTINGHOUSE SINGLE RETORT STOKER IMPROVED BY AIR DISTRIBUTING DEVICES

Furnace Wall Design Keeps Pace With Demands

STATEMENT BY COMBUSTION ENGINEERING CORP.

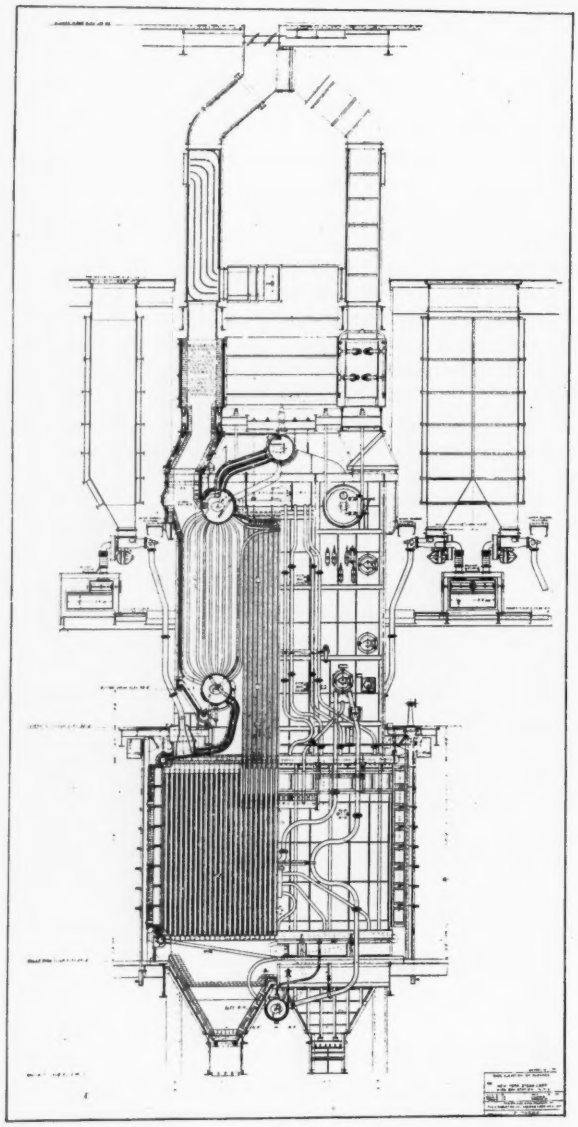
LOPULCO CURVED hollow wall construction for pulverized coal furnaces shown in the sketch is a distinct advance over the older type straight wall design. Tension stresses in the holding tile are eliminated by providing for expansion throughout the structure and the design of the air openings allows an even distribution of air to be maintained across the entire width of the furnace.

The trend in furnace design is toward complete



LOPULCO CURVED HOLLOW WALL CONSTRUCTION OF COMBUSTION ENGRG. CORP.

water-cooled walls as indicated by the installations at the Fordson plant of the Ford Motor Co., Kip's Bay Station of the New York Steam Corp., the Fourteenth Street Station of the New York Edison Co. and the Gould Street Station of the Consolidated Gas, Electric Light & Power Co. In addition to walls completely equipped with C.E. fin tubes and water screens these units are equipped with C.E. plate-type air heaters which effect the return of a considerable portion of the heat of the flue gas to the furnace, thereby reducing the stack loss and resulting in better combustion conditions. The trend in C.E. plate-type heater design



COMBUSTION ENGRG. CORP. STEAM GENERATOR AT KIP'S BAY HAS COMPLETE WATER-COOLED WALLS

is to space the elements closer together, thus obtaining a greater heat transfer from gas to air.

STATEMENT BY THE BABCOCK & WILCOX CO.

Because of the increased B.t.u. released per cubic foot of furnace volume resulting from the high rates of evaporation now demanded, it is becoming common practice, particularly in central station work, either to reduce or entirely to eliminate furnace brickwork through the use of furnace cooling tubes. Such tubes are either bare or covered with refractory block. The Babcock & Wilcox Co. feels strongly that the protected tube is the better construction.

STATEMENT BY M. H. DETRICK CO.

Within the last year the Detrick sectional-supported air-cooled wall has undergone rapid development. It has been installed in a number of the country's largest plants. This service record of this wall has modified considerably any feeling that air-cooled refractory walls in plants desiring high ratings might not be practical.

This wall has several interesting construction features. Each unit section 10½ in. wide by 30 in. high is supported independently of all other similar unit sections by an individual hanger casting. The load of the column of refractory tile comprising the unit section, is not carried by the tile immediately below but by the shelf of its individual hanger casting. Cumulative loading therefore cannot and does not prevail. The low bearing pressure which naturally results materially increases the service life of the refractory.

The wall tile are not only supported vertically at short intervals as described above but are also retained horizontally in a positive manner so that bulging of the tile into the furnace cannot occur. The individual unit sections are free to expand both vertically and horizontally. Each unit section of wall, 10½ in. wide by 30 in. high, is available for inspection or repair without disturbing or supporting any other similar unit section.

The cast-iron hanger bar conducts the heat from the interior of the tile to the air flowing through the air passages at a much greater rate than the tile itself would conduct it to the air. The flanges of the hanger bars project slightly into the air passages. This results in a series of small eddy currents and therefore a most effective bathing and cooling of the hanger flanges. The high conductivity of the cast iron combined with this fine effect makes for a maximum of heat transfer to the air flowing throughout passages, thereby lengthening the life of the tile materially.

Cost of erecting and repairing the inner lining of a wall equipped with this construction is much less than that of ordinary hollow or solid-type walls due to inherent details of its design, thereby justifying the original investment and resulting in a real economy in a short period of time.

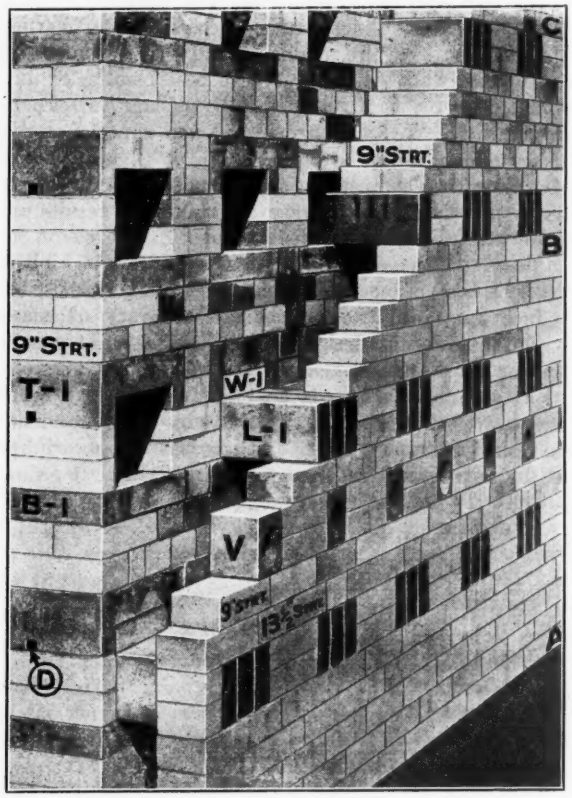
STATEMENT BY ERIE CITY IRON WORKS

One of our developments has been a water-cooled, refractory-lined, basket-type furnace for the combustion of pulverized coal. The vertical tubes in this furnace are connected by means of horizontal headers into the circulation of the boiler. The furnace wall consists of a steel casing lined with insulating material and the tubes are entirely surrounded by fire brick tile of special design. The bottom of the furnace is tapered to a restricted opening which does away with the necessity of water screen. The water cooling of the refractory wall allows high temperatures and corresponding high percentages of CO_2, without shortening the life of the refractory material.

STATEMENT BY LIPTAK FIRE BRICK ARCH CO.

Among the early designers and producers of special furnace wall construction was the Liptak Fire Brick Arch Co., of Mexico, Missouri. Originally, the idea behind their interlocking furnace wall construction was the easiness of installation and the saving of refractories due to the ability of this interlocking construction to transmit the weight of the service wall to the outer portion, which is the cooler portion of the wall.

With the gradual perfection of methods of increasing furnace efficiency it was necessary for the furnace wall construction also to be gradually changed and perfected and designed to meet specific furnace conditions found in different fields.



LIPTAK INTERLOCKING FURNACE WALL CONSTRUCTION: A TO B IS AIR-COOLED, 4½-IN. SERVICE LINING; B TO C IS SOLID 9-IN. SERVICE LINING

The present Type X wall is remarkable in its simplicity and at the same time it combines a large number of desirable features. It is an all-refractory wall and approximately 50 per cent of the entire construction is made from standard 9-in. fire brick shapes. Each unit is composed of four different blocks, all light in weight and easily installed.

The service lining, or the so-called inner lining, is definitely supported on the ledge tile, which transmits the weight to the outside wall. Each unit carries its own support and is individual from any other unit. This means that repairs can be made at any section of a lining without interfering with any other part of that lining.

It is designed both for solid wall construction and for air-cooled construction without any change in the units or the location of these units. Naturally, then it can be used as combination of air-cooled and solid wall in the same setting, if desired. The only difference between the two linings is that the fire brick for the solid wall are laid headers, while for a 4½-in. air-cooled wall the service lining is laid in stretchers. In installations where it is desirable to admit air from the ducts directly to the furnace proper Venturi block is furnished. These features are shown in the illustration.

The Type X air-cooled wall gives a 4½-in. service lining and a 4½-in. air space to cool this service lining. The air can be baffled so as to form either horizontal, vertical or a combination of horizontal and vertical intersecting air ducts. This interlocking wall, either air-cooled or solid, can be used in any thickness of wall and also in any height or width desired. Provisions are made in the outer retaining blocks for tying the wall to vertical steel buck stays or other tying members. This allows walls to be built to any height desired.

The flow of air through the 4½-in. ducts cools the service lining readily—remembering, of course, that the service lining is only 4½ in. thick. This prevents the brick from softening readily and also prevents slag from adhering to the brick. The danger from erosion is also decreased because the brick remain in their original hard state. The heat transfer through the service lining to the air ducts is high because of the thinness of this service lining. In fact, in actual installations one square foot of wall surface with a 4½-in. service lining and 4½-in. air space has delivered as high as 20 cu. ft. of air per min. preheated to a temperature of 440 deg. F. To insure the tightness of the service lining and to prevent short-circuiting of the air in the ducts, the Liptak Co. furnishes a super-high-temperature cement with a diaspore base to use for laying the fire brick.

The repairing of this Type X wall is a comparatively simple and inexpensive proposition. Only the service lining, which is 9-in. brick, and the ledge tile which support the service lining need ever be replaced. As the wall is built in horizontal panels independent of other panels forming the completed wall, any individual panel can be repaired without disturbing any adjacent panel.

STATEMENT BY MCLEOD & HENRY CO.

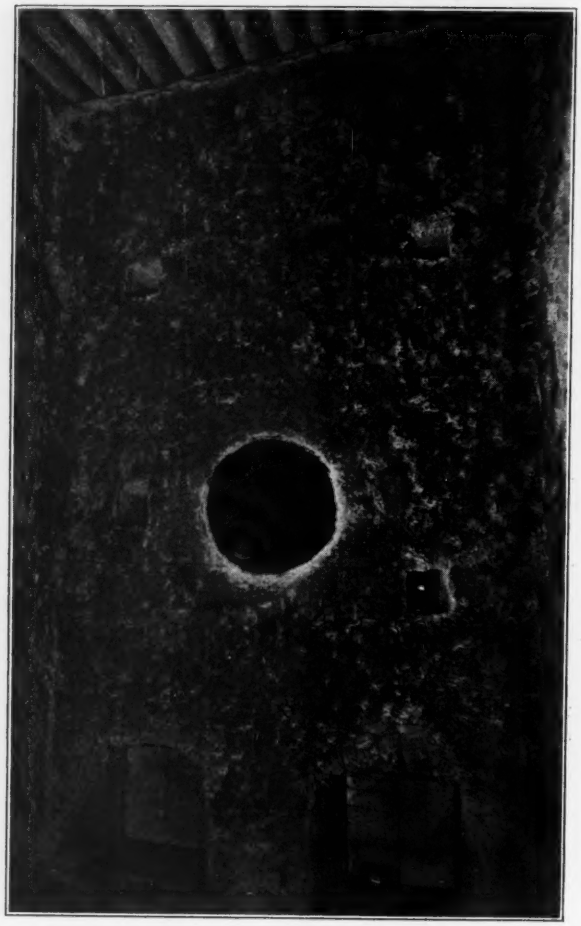
The McLeod & Henry Co. Steel Mixture Veneer Lining and air-cooled walls are being used extensively in modern furnaces for high rates of combustion. The Veneer Lining is for solid walls and the air-cooled walls for furnaces where preheated air for combustion purposes is desired.

Furnaces designed to burn powdered coal use both styles of lining. In one typical case, the front, sides and back walls are solid and use the Steel Mixture Veneer lining. The center wall is air-cooled. In these settings the amount of pre-heated air desired for combustion purposes is obtained through the air-cooled center wall alone.

The air-cooled wall is composed of a series of panels flexibly tied to the permanent core and suitably providing for vertical and longitudinal expansion. Provision is made for replacement of the outer header blocks in the design of the split-header anchor, which is of cast-iron. Although it has been our experience that repairs

are made, in walls of this kind, to large sections or the entire wall rather than to very small areas, it is our opinion that the greatest economy is obtained when the lining is so designed and constructed that the entire wall can be allowed to give its maximum service and then be replaced in one job.

The Steel Mixture Veneer lining used in the other walls of this battery of boilers provides by its design for maximum service and economy of repairs and replacements. In the design of the individual blocks and the assembled lining, due consideration has been given to the need for providing against the strains of expansion, contraction, explosion and final shrinkage. The



MC LEOD & HENRY CO. STEEL MIXTURE VENEER LINING IN FRONT WALL OF FURNACE AFTER 6 MOS.' SERVICE

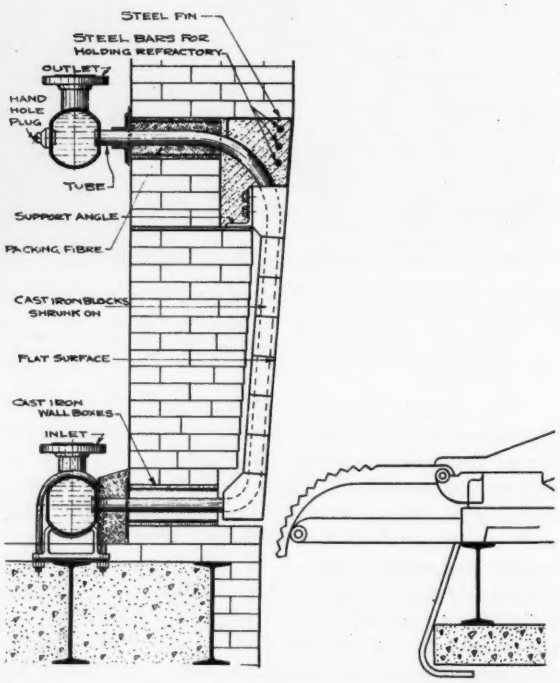
arrangement of header and tie-in courses reduces the vertical load upon the units and panels in the lower and intermediate portions of the Veneer lining so that it is not substantially greater at these points than at the top. Each section or panel may therefore expand more or less freely under temperature changes. This is facilitated to some extent by the construction providing for varying degrees of expansion in the inner or Veneer lining, the fire brick backing, and the outer lining. The temperature of the wall at points 4½ in. and 9 in. in from the fire face of the lining is proportionately lower than at the fire face and there is a natural tendency for different areas of the wall to expand or shrink more than others. It is this tendency that causes shearing and cracking. In the design and proportioning of the Steel Mixture Veneer lining this is reduced to a minimum. The photograph shows a Veneer lining in the front wall of a furnace after six months' service.

Repairs to a comparatively small area of Steel Mixture Veneer lining can be made if desired. The economy of material and labor for this operation is easily apparent.

STATEMENT BY POWER SPECIALTY CO.

Water-cooled furnaces and furnace walls are produced by the Power Specialty Co.; walls of bare tubing, complete walls of tubing covered with cast-iron blocks, modified walls covered with lighter blocks and walls consisting partially of bare tubing and partially of protected tubes have been used successfully in various applications. We are unable to find that a single type of furnace wall will produce the best results, or anywhere near the best results under difficult furnace requirements. We know from our own experience that this cannot possibly be the case, and it is essential that each furnace wall installation be studied in great detail if the purchaser is to receive the maximum results and those to which he is entitled.

It is not possible in a statement of this kind to describe the various applications and the means used to reduce slag and deterioration. These vary of course with the different designs of wall. The most specific answer is, therefore, that a wall completely protected with cast-iron covering is immune from damage unless the water circulation is cut off in some accidental manner. The ability of the cast-iron block to absorb heat at the face toward the furnace and distribute it around



FOSTER WATER BACK, MADE BY POWER SPECIALTY CO., IN A BRICK-SET BOILER; MANY VARIATIONS OF THIS DESIGN ARE POSSIBLE TO GIVE COMPLETE OR PARTIALLY WATER-COOLED WALL

the circumference of the tube rather than permitting high application of heat at one point on the tube is a fundamental difference between the cast-iron covered wall and other constructions permitting a high rate of heat transfer.

Provisions for repairs are similar to those in boiler tubes; that is, the removal of a tube which for any reason has failed in service.

Practice in Construction and Use of Air Heaters

Statement by The Babcock & Wilcox Co.

THE Babcock & Wilcox Co. has built both plate and tubular heaters and based on results in actual operation has adopted the single pass counter-flow design of tubular heater with inclined tube sheets as standard.

Statement by Power Specialty Co.

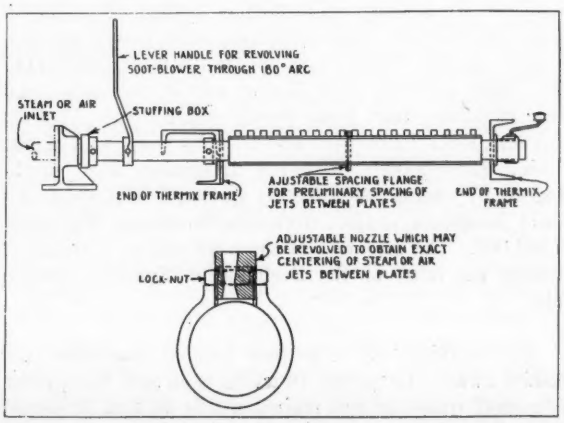
Power Specialty Co. manufactures air heaters to meet the various requirements as they come up, but does not advocate and manufacture a more or less standard type of air heater as a particular product, claiming great things for air heaters as compared with other methods of heat reclamation. It has been shown in a great many instances that the most efficient installation is a combination of small air heater and an economizer. Thus, unless you are limited to the product of such a special piece of apparatus it is unlikely that a manufacturer would approach the design of a power plant except with the idea of developing a combination which would produce the best results, regardless of whether it took more or less air heater, economizer, turbine stage bleeding or other means to produce the greatest economy for the customer.

Statement by Prat-Daniel Corp.

For use in connection with its Thermix air heaters, the Prat-Daniel Corp. has recently developed and placed on the market a rotating adjustable soot blower. Considerable development work on such a soot blower has been carried on for a number of years, but it has just been completed.

Proper cleaning of an air preheater is often important, especially with midwestern coals. The effectiveness of a soot blower for such work depends on the exact centering of the jet in the gas opening. If the jet is slightly off center, the sweep of the steam is interfered with and the plates may even be injured.

In practice it is impossible to place the gas sections of a heater within a fraction of an inch exactly as anticipated, since there is a large number of sections and a slight tolerance must be allowed. Primary spacing is first obtained by having the soot blower divided into sections of pipe with 10 nozzles, as shown in the accompanying sketch. These sections of pipe may be given a preliminary adjustment; the final adjustment is accomplished by the nozzle shown in the cross-section. This nozzle has its outlet parallel but eccentric to the center line of the opening in the pipe. When the jet is exactly set, the nozzle is locked in place by the lock nut.


LEVER HANDLE FOR REVOLVING SOOT-BLOWER THROUGH 180° ARC
STEAM OR AIR INLET
STUFFING BOX
END OF THERMIX FRAME
ADJUSTABLE SPACING FLANGE FOR PRELIMINARY SPACING OF JETS BETWEEN PLATES
END OF THERMIX FRAME
ADJUSTABLE NOZZLE WHICH MAY BE REVOLVED TO OBTAIN EXACT CENTERING OF STEAM OR AIR JETS BETWEEN PLATES
LOCK-NUT

ADJUSTABLE SOOTBLOWER DEVELOPED BY PRAT-DANIEL CORP. FOR USE WITH THERMIX AIR HEATER

Statement by B. F. Sturtevant Co.

Our latest practice in air heaters has been in connection with their application to power stations. Air heaters may be used to heat buildings, in process work and in certain other special cases, but there seems to be no great tendency in this direction. Having in mind this situation, we have designed our line of heat transfer equipment to give best results under the conditions which it is most apt to meet. The tubular type of heater is the one which has been most widely used, but the plate type has recently come into great favor. We have designs for both of these types, with certain new and useful improvements.

STURTEVANT PLATE TYPE AIR HEATER IS DESIGNED WITH REVERSIBLE ELEMENTS

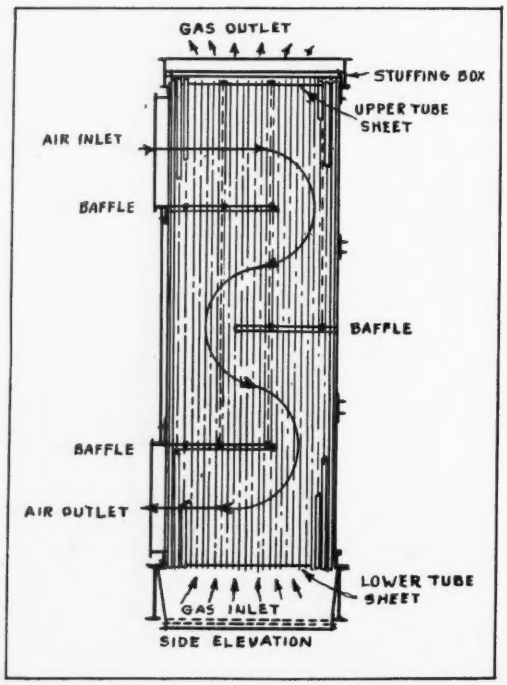
It is well known that cleaning and corrosion are the most important factors affecting the performance of an air heater. The cleaning problem assumes various proportions, depending mainly upon the installation and type of fuel. High gas velocities are the best means of keeping ahead of this problem but if, in spite of the velocities, the soot becomes troublesome, it must be removed by additional equipment. Soot blowers or hand lances are used and often a soot hopper properly located will aid materially. Under such conditions that heater whose elements are most accessible will prove the easiest to keep clean.

Our plate-type heater is fitted with doors, which

render the entire gas side of the heater accessible, and there is, therefore, no point in the heater where soot can lodge unnoticed. The heater is so accessible that it can be easily cleaned when necessary by a hand lance or a stiff brush or, if necessary, a soot blower installation.

Similar considerations apply in the case of the tubular heater. If the gas is put through the tubes, cleaning is not a serious problem. Sometimes the conditions require the gas to pass around the outside of the tubes and in such cases a proper number and location of inspection doors is necessary, to facilitate the cleaning process.

Corrosion and cleaning are so closely allied that conditions affecting one invariably affect the other also. Corrosion is not so apt to occur on the cold end of the heater while in service but does occur when the machine



STURTEVANT TUBULAR-TYPE AIR HEATER WITH LEAD-COATED TUBES

is out of service. Under either condition, if any spot becomes wet from any cause, the soot will collect at that piont, start a miniature sulphuric acid plant, and thus cause excessive corrosion over a restricted area. This action, once started, continues unabated, since the acid cannot be driven off except under high temperature, and even if this is accomplished the residue can be removed only by extra effort. In such cases a heater which is really accessible can be properly cleaned.

We advocate the use of copper bearing steel sheets for plate heaters, and our special lead alloy coating for tubular heaters. Both of these suggestions have been tried and found satisfactory, especially the lead alloy coating, which we have applied to our steel tube economizers with remarkable results.

Our plate-type heater has an added advantage due to the removability and reversibility of the plates, which are made up in individual elements. By simply loosening a few nuts any element may be removed through the back of the heater, turned end for end and replaced, thus presenting fresh surfaces to the cold end and retiring the former cold end of the element to the hot end, where the corrosion is less active. This feature lengthens the life of the heater and gives it a better chance of being a justified investment.

We have found that the lead coating used on the tubes will withstand the severest kind of corrosion conditions, as well as erosion. However, tubes are such a standard product that it is an easy matter to obtain and replace one in case of failure, in exactly the same manner in which boiler tubes are replaced.

Air heaters are being applied with marked success to boilers which are fired by any of the modern methods. Consideration must be given to the effect of the heated air upon the moving parts of stokers; the concensus of opinion seems to point to about 425 deg. F. as a limiting final air temperature. However, stoker designers are keeping abreast of the problem and the stokers are performing satisfactorily in spite of the concern which was expressed over the possible effect of high temperatures on the ash of certain coals. The beneficial effect of heated air upon powdered fuel, oil and blast furnace gas installations has been thoroughly demonstrated. Combustion is much more rapid with the immediate effect of higher furnace temperatures and better heat transfer. A secondary benefit of accelerated combustion yet to be realized is the possible reduction in furnace volume, pointing toward a lower investment. There is no system on the market at present which takes full advantage of all these possibilities and the writer knows of only one proposed system which approaches the ideal conditions.

Government Power and Irrigation Projects

THE DEPARTMENT of the Interior, Washington, D. C., has specifications and plans under way for power and irrigation projects to cost about $97,000,000. The program for the most part covers the completion of different enterprises in western territory now under way, and includes the following: American Falls reservoir and power development, and the Minidoka power development, Minidoka, Idaho, $8,423,000; Arrowhead and Payette projects, Boise, Idaho, $6,334,000; Gibson reservoir and Fort Shaw distribution system, Sun River, Mont., $3,653,000; Vale irrigation and power project, Oregon, $3,115,000; Owyhee project, Oregon, $17,714,000; Echo reservoir and Weber and Provo canal and other divisions, Salt Lake Basin, $12,400,000; Cleelum reservoir, Rosa, Pennewick and Kittitas projects, Yakima, Wash., $25,579,000; Riverton irrigation and power project, Wyoming, $5,195,000; Garland, Willwood and Heart Mountain project divisions, Shoshone, Wyoming, $5,193,000. The majority of the work will be carried out through the office of the Reclamation Service, Denver, Colo.

AIR CYLINDER oil is neither burned, vaporized nor washed away. Its prime function is to seal the piston. As a small quantity will maintain this oil film, it should be used sparingly, only enough being supplied to keep the walls and valves slightly greasy.

FEED WATER PREPARATION

Feed Water Heaters

STATEMENT BY THE COCHRANE CORPORATION

IN THE FIELD of feed water heating the modern deaerating type of feed water heater is an important factor in the elimination of corrosion of boiler surfaces. The rapid destruction of piping, boilers and economizers is generally due to oxygen corrosion. Water from city mains contains from four to seven parts per thousand by volume of dissolved oxygen which for each 1000 lb. per hr. capacity is capable of dissolving away and converting into rust from 170 to 260 lb. of iron per year.

The elimination of oxygen from a water supply is comparatively simple where the water is also to be heated, since oxygen like most other gases, is insoluble in water heated up to the boiling point.

The new Cochrane deaerating heater deaerates the water perfectly while delivering water at any temperature wanted; in fact, the temperature of the water may be allowed to vary continually, if desirable. The steam supply for a deaerating heater may be the exhaust from engines and pumps, or it can be bled from the main turbine. A Cochrane steam check valve in the bleeder connection prevents back flow of the steam to the engines or turbine.

Where the deaerating heater receives all of the exhaust from a turbine, the latter can have the benefit of a vacuum corresponding to the temperature to which the water is heated, with a considerable improvement of the efficiency of the turbine as compared with exhausting to the atmosphere. The deaerating heater really serves as a condenser for the turbine, using as circulating water that which is supplied to the heating system. Deaerating heaters are now made so that they can be operated at any pressure within the range of the steam supply available for use in the heater and at the corresponding temperatures.

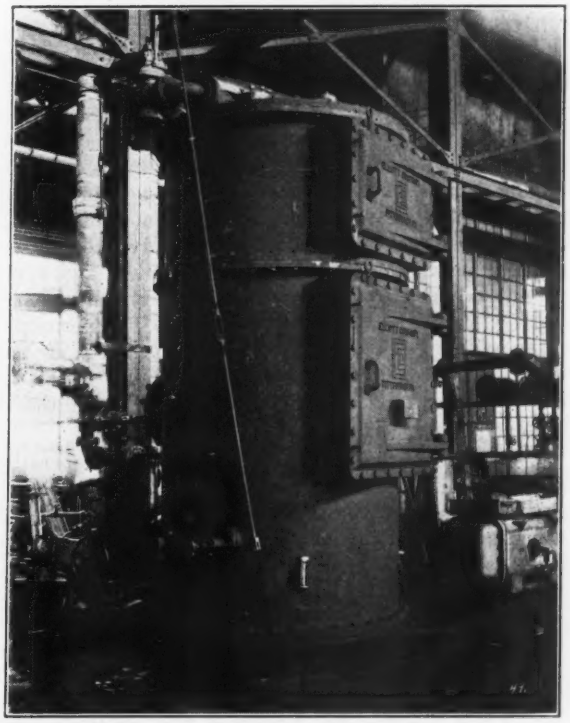
Where a heater is operated under pressure, that is, above atmospheric pressure a simple vent through a vent condenser is all that is necessary for deaerating the water. For low pressures the vent line must be either led to a condenser or a steam jet or a mechanical air pump can be used. The present tendency is perhaps toward the use of mechanical pumps, where possible, in order to eliminate the high steam consumption of steam jets.

For use where upwards of 200,000 lb. of water must be heated per hour, the Cochrane jet heater is recommended. It heats the water close to the steam temperature and is particularly efficient under heavy load. It can be operated under back pressures or vacuums changing automatically from one condition to the other, according to variations in the flow of feed water or in the supply of exhaust or bled steam. This type of heater is not recommended where there are long periods of operation at small fractional loads, where ample head between heater and boiler feed pump is not available, where the water cannot be supplied under sufficient pressure to give efficient spraying, where complete deaeration is required or for small and moderate capacities.

STATEMENT BY THE ELLIOTT CO.

No increase in capacity has marked the deaerators manufactured during the past year. The largest deaerator in use is a unit rated at 900,000 lb. per hr. but this has been installed for several years. The most recent development is a deaerator with a capacity of 750,000 lb. per hr.

The tendency of purchasers during the past year is toward deaerating heaters rather than deaerators. The apparent commercial attitude is to purchase the cheaper article and give it the amount of operating supervision required to make it work. Fundamentally, the difference between the deaerating heater and the deaerator is the fact that the deaerating heater is a simpler structure which does not have as many frills to take care of operating irregularities as the deaerator. In other words, many of the minor guarantees for perfect operation in the deaerator are eliminated in the deaerating heater. The result is a considerable cheapening in price

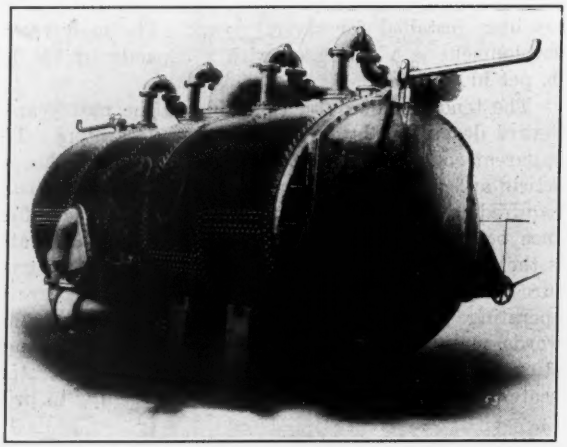


ELLIOTT VERTICAL CAST-IRON DEAERATING HEATER

and the purchaser is taking advantage of this and applying operating attention.

It is probable that the true interpretation of this change is the fact that the rank and file of operating men have come to realize more the needs of deaeration and how to secure it, and that the art, as a whole, has gotten beyond the stage of operating mystery and as a result people understand it better and can operate it more intelligently.

There has been no radical change in deaeration methods; no new forms of apparatus have been put on the market, and equipment has become stabilized as far as proportioning and operating theory is concerned. The open-type unit in which steam and air is brought in contact in two stages is still the most popular; partly, because it is low in price and partly because it is higher in heat efficiency, heating water to the temperature of the steam.



750,000-LB. PER HR. ELLIOTT STEEL PLATE DEAERATING HEATER

There has been a decided increase in the use of deaerating heaters on stage extraction of turbines. These have been of various types, some of them steam contacting devices with elaborate protective control to avoid the possibility of water getting back into the turbine and some others, in which tube banks are used to separate steam and water. These various ideas and applications occur with different firms of consulting engineers. As far as operating experience has permitted, one method seems to be as good as the other, in that there have been no turbine wrecks from the use of the direct mixing type of unit where the potentialities of danger are apparently high.

With the use of turbine stage extraction, operating pressures in the deaerator shell have risen remarkably, so that it is now true that deaerators, instead of operating under a vacuum, as formerly, now operate at pressures as high as 40 lb. absolute with corresponding water temperatures. The standards of construction have changed accordingly in some cases, where high pressures are involved, from cast iron to some form of rust-resisting plate such as ingot iron or wrought iron. The pressure standards of riveting are ordinarily those of the A.S.M.E. code for pressures two or three times higher than the contemplated standards of operation.

This change in operating pressure has put the problem of auxiliary apparatus squarely up to the manufacturer and there has been a lot of work done on these auxiliary devices during the past year. By auxiliary devices, we mean primarily automatic valves for the control of steam venting or the control of inlet water, and for the control of overflow. Adequate valves have not been available sufficiently balanced for the control of inflow water, particularly at low loads.

It has also been necessary to develop overflow valves to take care of excess quantities of water and afford protection to the turbine against water coming over from the deaerating heater into the turbine stage line.

A deaerating unit floating on a turbine stage, of course, undergoes changes in operating pressure with changes of turbine load, and it is always necessary to contemplate the operation of the unit under vacuum. It is uniformly true that all forms of balance, double-seated valves in large sizes are subject to warping, casting growth, etc., so that these valves cannot be depended upon to be permanently tight. Vacuum leakage is, of course, disastrous to turbine operation. As a result, it has been necessary to develop single-seated valves which would function under both pressure and vacuum, be of large pipe size, and still be readily controlled by floats of reasonable and commercial size.

The market for deaerating equipment is constantly widening with the small plants and in the small-sized units. There is a much larger sale of small deaerating heater units to the industrial plants than there was a year ago. To a certain extent, this acceptance of deaeration is imitation and largely conventional.

There have been no extensions of deaeration to other fields, other than the bottling industry and the ore flotation.

In the bottling industry the presence of air largely interferes with the vitality of carbonated liquids and as a result, there is now a demand which the Elliott Company is supplying for a small cold water deaerator for the removal of air from water, subsequently to be used in pop, ginger ale, etc., before carbonation occurs.

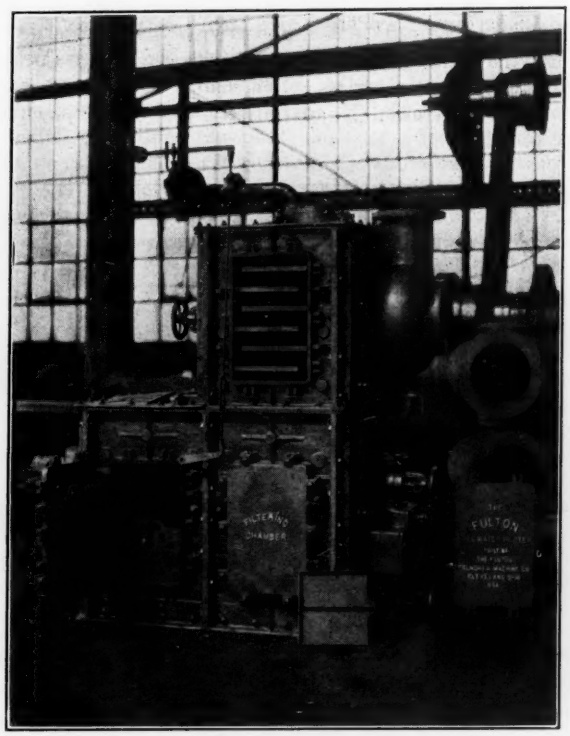
There seems to be a real field for partial deaeration in the flotation industry in mining. The requirements, however, are not nearly as severe as for power plants and the prevention of corrosion.

The field of cold water deaeration for commercial usage has not grown to any extent. It is possible now to offer cold water deaerators, but ordinarily the cost of them is quite high, largely because of the prodigal use of cold water. Cold water deaerators when applied to specific applications, such, for instance, as deaeration of water supplied to a hotel, are impractical because of the huge quantities of water involved and the consequent size of the deaerating equipment. The most pertinent observation, of course, is that most of the cold water is wasted.

The use of deaerators in protecting hot water piping in buildings continues to grow at an even rate, but the growth has not been spectacular nor is the use of this equipment a significant feature in deaerating equipment sales. It is very much of a side line and apparently will remain so for several more years; or until there is a greater economic distribution of cost between brass and iron pipe.

STATEMENT BY THE FULTON FOUNDRY & MACHINE CO.

While no particularly new developments have been made in the Fulton open feed-water heater, we wish to emphasize the unit type of construction employed. With this system, additional steam or storage sections may be added readily without disconnecting the exhaust piping, and at small expense in changing the suction and water piping. Being constructed of cast-iron sections there is nothing to rust, warp or wear out. The plates are heavily ribbed to give the required strength and are made tight at the junction



A THREE-UNIT, FULTON HEATER WITH TRAY DOOR REMOVED SHOWING ARRANGEMENT OF TRAYS

plates by a specially-designed joint, which will not leak.

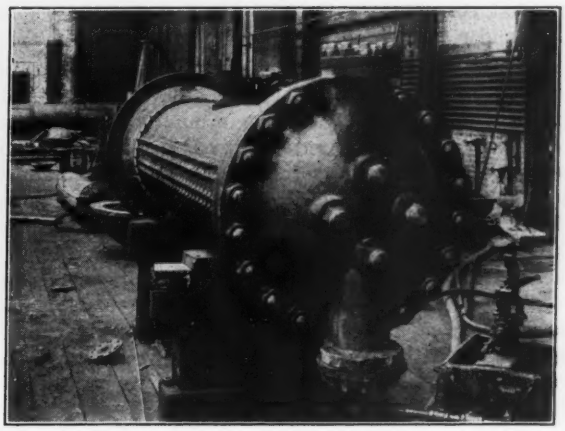
In the upper section of the heater are provided trays or pans, held in place by tray racks which are supported on cast-iron lugs forming part of the plate structure and which carry the entire weight of these internal parts. The tray racks are securely bolted to these lugs. The trays slide in grooves cast in the tray racks and are easily removed for cleaning. The incoming make-up water to be heated enters the heater at the top, and discharges into the spray box through a tube, the end of which is submerged within the spray box. The sealing of this opening prevents steam from entering this water inlet pipe and heating the water inlet control valve. Access for removing trays and cleaning is through a large manhole with hinged manhole door. Openings are provided on top of the heater for returns from heating system, vacuum pump, and traps. These returns are heated to the temperature of the steam passing over the trays.

The lower section of the Fulton heater is made deeper than the upper section to give increased water storage space. This storage space may be utilized to store water of condensation by maintaining a low normal water line. By carrying a higher water line an increased storage for boiler supply is available.

In the accompanying illustration is shown a three-unit, right-hand, Class "A" Fulton heater with tray door removed, showing arrangement of trays; also a sample tray. One filter door is open showing the coke retainer plate. This filter is typical of all sizes.

STATEMENT BY THE WHEELER CONDENSER & ENGINEERING CO.

There have been few changes in the design of heaters for extraction heating. The increased use of extraction in three or more stages with the higher stages on the discharge side of the boiler feed pump, has necessitated the design of heaters for high pressures in the tubes and headers. The Wheeler Condenser & Engineering Co. is building heaters for 900 lb. working pressure within the tubes and channels and 1200 lb. test pressure. The boiler pressure in the station in which these heaters will be installed is to be 850 lb., the boiler feed pumps holding approximately 50 lb. excess pressure. In the accompanying cut of a high-pressure



HIGH-PRESSURE EXTRACTION HEATER OF THE TYPE BUILT BY THE WHEELER CONDENSER & ENGINEERING CO.

heater, you will notice the heavy staybolting of the water boxes, and the steel construction. Heaters, such as extraction heaters, which handle clean water, are provided with headers of the type shown in the photograph in which the entire water box is cast in one piece without water box cover. This construction is stronger than the usual design, with a separate water box cover, and is employed wherever it is not necessary to clean the tubes frequently.

It is the opinion of the Wheeler Condenser & Engineering Co. that evaporators and heaters could be advantageously employed in stations much smaller than those now using them. It is as desirable to be able to run at a high rating in a small station as in a large one. In fact, a small station, or industrial plant, has usually a more uneven load curve than a central station. Feed-water heaters, in addition to saving coal, often make a smaller condenser possible and produce other economies.

Water and Steam Purification

STATEMENT BY THE BLACKBURN-SMITH CORPORATION

BLACKBURN-SMITH feed-water filters and grease extractors were originally designed and first introduced into land work over 15 yr. ago. These filters use specially woven linen terry cloth as a filtering medium. This cloth is contained in the filters in a number of small cylindrical cartridges so constructed as to give two successive and separated filtrations and the service is based on the absorptive qualities of the cloth. Such filters have been used for many years in marine work where the amount of oil fed into the cylinders of steam engines is small, and on that service the filters have large capacity per unit area of filtering medium. This is also due to the use of perfectly clean water with respect to organic matter and dirt.

In land work the water is often quite dirty and contains much organic matter, thus calling for filters of larger capacity on the same basis as just mentioned. It is also a fact that most of our installations have been made in plants which for many years were throwing away water of condensation, an action that wasted heat and at the same time did not prevent oil collecting in the piping. The use of the filter in such plants saves the heat contained in the water, also saves the water itself and results in an important economy in the plant.

Naturally, the use of the filter for so many years has left very little room for recent developments and the principal one which we have in mind at the moment is the changing of the ratings given in our catalogue to conform to the information which we have obtained through the many years of installing and operating these filters. It was also necessary practically to make a new start in the manufacture of the terry cloth due to the fact that during the war and for some years thereafter no linen yarn such as required was obtainable, and therefore a comparatively unsatisfactory cotton yarn had to be substituted. We have now developed a cloth which we consider fully equal to any which we had before the war.

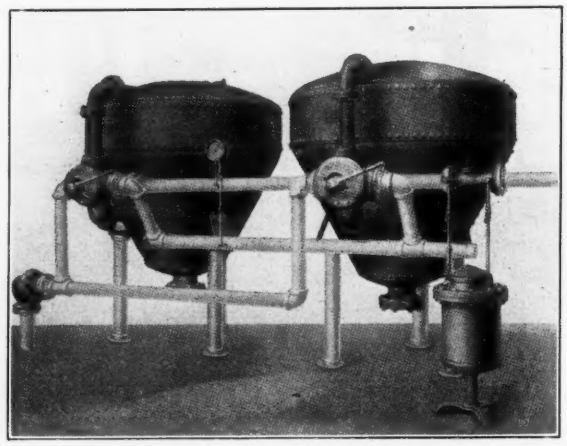
We have also developed a process for so treating water containing emulsified oil as to filter this out of the water, leaving a feed water clear enough to drink. This calls for a little extra attention in that a chemical must be introduced into the water in measured quantities at definite intervals and most engineers including ourselves do not feel that the advantages obtained are sufficient to compensate for the extra trouble. Sufficiently good results can be obtained by simple mechanical filtration.

The Blackburn-Smith Multiduct Strainer was originally intended for the removal of leaves, twigs, etc., from river or lake water. We have furnished a number of strainers to various manufacturing concerns for special services; for example, lining the baskets with fine wire cloth has given us a strainer which protects valves, faucets, etc., in a city building where the water contains sharp sand. Such strainers have also been used to clean up brine used in refrigerating systems. We have made strainers entirely of iron and steel for handling ammonia liquors in coal distillation processes and also for handling alkalis in process of manufacturing. A very interesting service has been the installation of a strainer of a certain mesh basket in the circulating line of swimming pools. The strainer is installed just before the sand filter and increases the periods of operation between cleanings of this filter by removing the dirt, hair, etc., contained in the pool water. These baskets are so constructed as to permit of the deposit being burned off in the boiler furnace.

From the standpoint of construction we have made these strainers sufficiently strong to carry 100 lb. working pressure, thus departing somewhat from the tradition that such strainers could be used only on suction lines.

STATEMENT BY THE COCHRANE CORPORATION

In the field of feed water purification, the Cochrane conical strainerless filter shown in the accompanying illustration is an entirely new development.



DOUBLE UNIT COCHRANE STRAINERLESS FILTER WITH SINGLE CONTROL VALVES AND COAGULANT FEEDER

This filter does away entirely with the use of collecting manifolds and strainer heads. The office of the strainer valves is performed by a proper shaping of the body of the filter container and using an uptake cone for taking off the clarified water. The incoming raw water is brought into the top of the filter tank and is distributed by a baffle over the top of the sand bed. It then passes down through the sand bed and the gravel bed up into the takeoff cone and out into the pump or clear water basin. The actual work of filtration is done at the top layer and is complete after passing through an inch or two of the filter sand, the remaining sand and gravel being required only in order to secure a proper foundation for the top layer and to prevent channeling or short-circuiting.

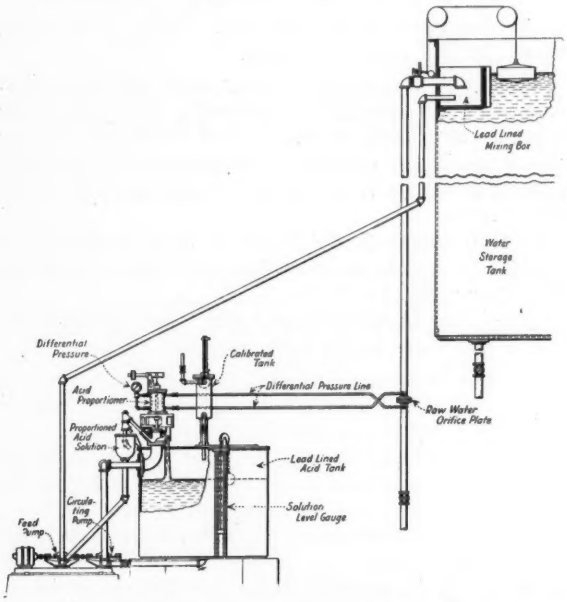
The filter bodies are constructed of steel plate, well riveted and in three standard weights, for 65, 100 and 125 lb. pressure per square inch. A gate or door at the bottom or apex of the filter body permits of discharging the filtering material by gravity while a manhole is provided in the top for re-charging. The external piping and valves, as well as the arrangement for feeding coagulating chemicals, are the same as for the cylindrical filters.

The top layer of sand is of the same proportions and

makeup as that in the standard type of filter and has a filtering rate figured on the same basis, namely, from 2 to 5 gallons per square foot per minute, depending on the character of the waters, service conditions, etc. Underneath the layer of fine sand are two layers of gravel and beneath that a layer of crushed stone. Embedded in the latter is an inverted open cone, from the apex of which the water is withdrawn through a pipe.

The recent developments of the Cochrane Corporation in the field of water purification by chemical treatment have been thoroughly covered in an article by J. D. Yoder appearing on page 1316 of the December 15, 1926 number of Power Plant Engineering. In this article, in addition to giving a brief resume of developments in the lime and soda softener, Mr. Yoder discussed the experiments with the use of tri-sodium phosphate in place of sodium carbonate. It was found that the use of tri-sodium phosphate did not offer any appreciable advantages over the use of sodium carbonate.

Another development of the Cochrane Corporation, and one which was discussed by Mr. Yoder, was the design of an equipment for feeding sulphuric acid to



COCHRANE SULPHURIC ACID FEEDING EQUIPMENT

the feed water in order to maintain the proper sulphate carbonate ratios. A brief description of this feeding equipment will be given here.

The flow of raw water through an orifice in the piping which conducts the water to the storage tank creates a differential pressure which acts downwardly upon a piston. The downward force is balanced by an upward force maintained on the underside of a valve disc mounted on the piston rod. This valve disc is of the same area as the piston, so that the liquid pressure underneath the valve disc is at all times equal to the differential pressure on the piston and at the raw water orifice plate. The liquid pressure on the valve disc is maintained by a circulating pump which draws the acid solution from the bottom of a lead-lined acid tank and discharges to the chemical proportioner. The circulating pump has capacity to discharge against a higher head than will be imposed on the disc by the differential pressure on the raw water orifice so that some of the chemical solution always discharges from this valve and falls into the solution tank in a continuous stream, as illustrated in the accompanying figure.

STATEMENT BY THE DEARBORN CHEMICAL CO.

In the field of internal water treatment the big advances are advances in the scientific interpretation of the reaction going on in the boiler and the better composition and adjustment of treatment to take advantage of these reactions with minimum amount of treatment.

During the year we have perfected the manufacture of a pure grade of liquid sodium aluminate varying between 26 per cent and 30 per cent of available aluminum hydrate, a content carried even higher than that of solid crystalline alum. The combination of the pure aluminate in exceedingly small dosages in conjunction with treatment is making possible the use and control of

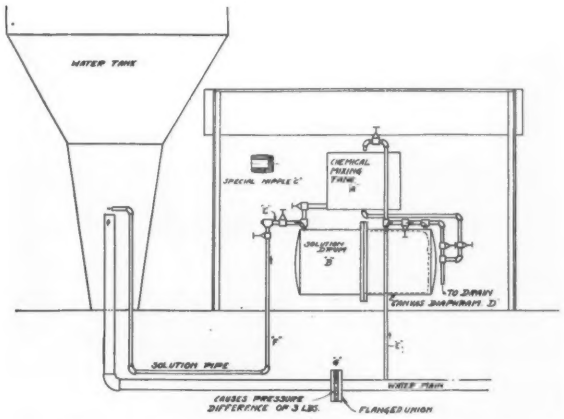


DIAGRAM OF NEW FEEDER DEVELOPED BY THE DEARBORN CHEMICAL CO.

any type of water which did not fit into our previous methods. Furthermore, the use of a coagulant in conjunction with treatment making it possible to carry the mineral content of the water somewhat higher than would be the case otherwise.

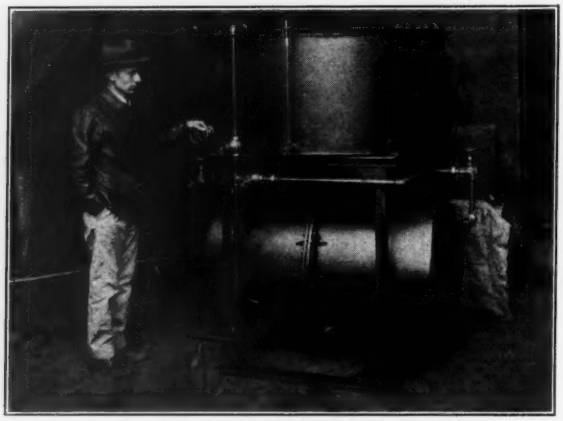
We find, in actual practice, where certain types of controlling vegetable material are part of the treatment, that even in the pure water ice plants water concentration can be carried between 600 and 700 grains per gallon with no serious contamination, and we have many cases where the steam produced with a concentration between 350 and 400 grains per gallon of water shows only 1½ to 1¾ grains of solid per gallon in the condensate. We are controlling the mineral concentration by methods of titrating samples of water collected from the boiler proper using the chlorine titration as an indicator of the total solids in the water and adjusting the blow-off so as to keep the rate of concentration under a fair degree of control. We have, during the latter part of the year, put out a compact small type of feeder for the treatment outside of the boiler which is very marked improvement over any previously conceived type of manufacture. A diagram of this equipment is shown in the sketch and in the photograph. It is essentially an arrangement for automatically feeding Dearborn scientific water

treating preparations into a flow of untreated water in exact proportion to the rate of flow of the untreated water. The plant has no pumps or moving parts to get out of repair and thus interfere with correct treatment.

It always exactly proportions the flow of the solution to the flow of water, and it operates only when there is an actual flow of untreated water. As may be noted from the illustration, it consists of a chemical mixing tank, A, with chemical mixing basket solution drum, B, with diaphragm bag, and all necessary valves and piping. The operation of this equipment is as follows:

The treating chemicals are dissolved in chemical mixing tank A; to charge the plant the solution in tank A is let flow by gravity to solution drum B. This drum is in two halves and held between the flanges of these halves is a canvas diaphragm that conforms to and loosely fills one-half of the drum.

The solution entering the solution end of the drum forces the diaphragm across to the opposite end until the drum is full of solution. At the same time, water that has



A VIEW OF THE DEARBORN WATER TREATING EQUIPMENT SHOWING ITS COMPACTNESS

accumulated in the water end of the drum is forced out of the drum and into the outside drain or sewer, thus the solution drum is charged.

The water main leading through supply tank has inserted in it a flanged union between the two sides of which is held a metal plate G. This plate has a hole in it of such size as to cause in the average flow of water a back or excess pressure of about 3 lb. per sq. in.

From the higher pressure side of this plate G a 1½ in. pipe leads to the water end of solution drum B. Another small pipe leading out from the solution end of the drum conveys the solution to the supply tank where it mixes with and treats the incoming water. The reason why any solution should flow to the large supply tank is not apparent from an inspection of the plant, but it is as follows: When water flows through plate G, a back pressure is caused by virtue of which part of the water is by-passed through pipe E, to the water end of the drum. The diaphragm is gradually pushed toward the opposite end of the drum forcing the solution out through pipe F, and up into the water tank.

The rate of flow of solution is in turn controlled by means of a constriction in the treatment line at a special nipple C. This nipple is blanked at one end except for a hole $\frac{3}{32}$ in. in diameter. At 3 lb. back pressure the flow through this hole would be about 20 gal. per hour. The relative amounts of solution in water flowing depend on the relative areas of the two constrictions at C and G.

A 2 in. hole at G would mean that the amount of water flowing would be 450 times its rate as the flow of solution through a $\frac{3}{32}$ in. hole at C, the areas of the two holes being as 450 to 1. When water stops flowing the excess pressure, of course, disappears and consequently the flow of solution stops.

The drum is designed to hold enough solution to last at least 24 hours at the average water station. The only attention the plant needs is to make up the specified quantity of Dearborn Treatment once a day and start the drum in operation, requiring perhaps 20 minutes.

The unit is made in two sizes, the larger unit occupying a floor space of about 6 by 7 ft., and is 8 ft. high, the dimensions of the small unit are 4 ft. 3 in. by 5.3½ in. in height. It will require a floor space of about 5 ft. square.

Statement by The Hagan Corporation

Briefly the Hall System of Boiler Water Conditioning as practiced at present with Hagan Equipment, consists of four essential factors.

First: A treatment (usually soda ash or sodium phosphate) for chemically conditioning the water in the boiler, the systematic maintenance of which will prevent scale formation by causing all precipitation in the boiler to occur as sludge rather than as scale, and which will inhibit corrosion.

2nd: Instruments which can be used by any boiler operator to determine and adjust the conditions within the boilers under his charge.

3rd: The De-Concentrator for mechanically conditioning the water in the boiler, so as to reduce the suspended solids.

4th: A Steam Purifier to insure the delivery of clean, dry steam.

This method of chemical treatment is based upon the co-operative investigation between the United States Bureau of Mines and the Hagan Corporation, for a period of over four years. The results of this investigation, which have been published from time to time by Dr. R. E. Hall, under whose direction the investigation was conducted, have been completely confirmed in practice. No changes in the theory underlying the treatment have been necessary.

The mechanism of silicate scale deposition has been found to be exactly analogous to that for sulphate scale deposition, and means for its prevention are thoroughly known. In the case of most feed waters, the concentration of the treating chemical in the boiler necessary for the prevention of sulphate scale, automatically prevents the deposition of silicate scale. In some waters containing little sulphate and considerable silica, differing concentrations of treating chemical are necessary, but in these cases the conditions which prevent the deposition of silicate scale then automatically provide protection against the deposition of sulphate scale.

It is felt that any system of boiler water treatment should maintain the water in the boiler in accordance with the tentative recommendations for the prevention of caustic embrittlement. Customary methods for main-

taining these conditions (such as the use of sulphuric acid sulphate, sodium sulphate, etc.) may in high pressure boilers, afford this protection only by increasing the likelihood toward scale deposition. By the use of the proper form of sodium phosphate, it has been found possible to maintain those conditions under which caustic embrittlement has never been known to occur, and at the same time insure that the hardness in the water coming to the boiler, whether this water has been pretreated or not, will precipitate as non-adherent sludge rather than as adherent scale.

The Hagan Testing Cabinet and Concentration Gauge, have been improved in minor details, making the periodical tests of the boiler waters exceedingly simple and quick, yet sufficiently accurate.

The De-Concentrator which withdraws water from the boiler, filters it and returns it, has been changed but little during the past year. The periodical washback for cleansing the filter bed, is made expeditiously at intervals depending upon the amount of suspended material which forms in the boiler. The blowdown of the boiler may then be restricted to that value necessary to keep the concentration of dissolved material within proper limits, and can be controlled in accordance with the daily determinations of boiler concentrations.

A motor-driven centrifugal circulating pump has been developed for the De-Concentrator to replace the Reciprocating Pump hitherto supplied, where electric drive is found desirable. The De-Concentrators supplied for the East River Station of the New York Edison Co. have been equipped with this type of Circulating Pump.

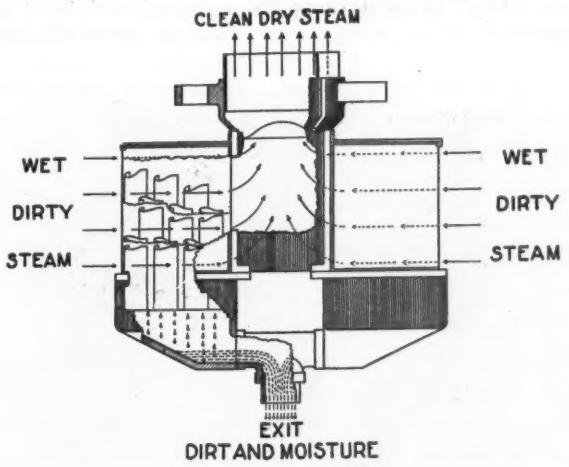
The basic design of the Hagan Steam Purifier has not been altered. The Hagan Purifier being of the high velocity type, can be compactly designed for installation in steam lines, and a large number of such installations have been made during the past year. A purifier satisfactory for use within a boiler is necessarily more efficient than that type of separator in common use in steam lines. Besides possessing this advantage, the Hagan External Purifier provides a method of cleaning the steam from certain types of boilers in which the installation of an internal purifier is attended with grave mechanical difficulties or other undesirable features.

Statement by The International Filter Co.

In the field of water purification the International Filter Co. has recently developed a new steam purifier which is exceedingly effective in its performance. This purifier is founded upon the law that all bodies set in motion tend to move in a straight line. The steam flows through it in thin bands or ribbons which are given an undulating or waving motion by means of shaped passages between parallel plates or panes. While the steam readily changes its direction of flow to conform to the shape of these passages, any liquid or solid particle present, due to their relatively high density, are projected into scrubber pockets on one side or the other. This action is shown by the accompanying illustration.

Since this action is more efficient at high velocity than at low velocity, the purifier may be of small size. This is an important feature, since the device must be installed in a limited space, further, since only slight changes in the direction of the steam flow are required, the pressure drop through the International purifier is scarcely detectable, even at high velocity. Also, the pocketing of the impurities so that they are protected from any further action of the passing steam is a very important advantage.

The objectionable particles of moisture and wet gritty matter must not be allowed to get back into the steam once they have been expelled from its path. This is accomplished in the International purifier by collecting such impurities in scrubber pockets into which they have been projected as explained above. Here the impurities are completely protected from any scouring action of the steam which tends to tear loose and carry along anything held merely by adhesion to an exposed surface. This is particularly important with very wet steam, because the amount of moisture may then be more than can be held by an exposed surface, resulting inevitably in some moisture being carried along.



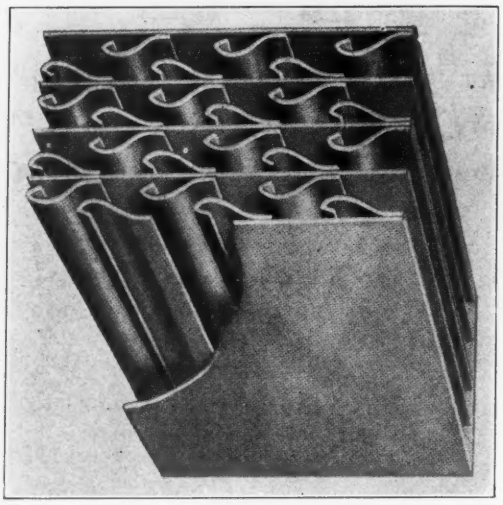
A DIAGRAM OF THE INTERNATIONAL STEAM PURIFIER WITH SIDE CUT AWAY SHOWING OPERATION

Protection of the impurities from any further action of the steam immediately upon their separation therefrom is an advantage exclusive to the International purifier. Further, the scrubber pockets of the International purifier by which this protection is secured, are of sufficient capacity to drain off even large floods of water.

DIAGRAM SHOWING PASSAGE OF A STEAM BAND BETWEEN TWO VANES AND THE COLLECTION OF THE IMPURITIES IN THE ALTERNATE SCRUBBER POCKETS OF THE INTERNATIONAL STEAM PURIFIER

A group of the International purifier drains, which are carefully rounded scrubber pockets is shown in one of the accompanying illustrations. The entering steam is divided into thin band-like streams which are purified and collected in suitable chambers connected to the steam nozzle of the boiler drum.

The moisture and impure matter collected in the vertically placed scrubber pockets drain downwardly into a suitable collecting chamber below and are then expelled from the boiler by means of a drain line and discharge trap outside. The foreign matter removed from the steam is not permitted to return to the water in the boiler but by this means is passed entirely to waste or sewer outside. This avoids increasing the concentration of impurities in the boiler water, and therefore also avoids increased blow-down. The purifying compartments contain evenly spaced plates or vanes at the sides of which the scrubber pockets are welded. The scrubber pockets of adjacent vanes are so placed that those on one side of the passage, round into the spaces of those



SECTION OF THE PURIFYING COMPARTMENTS OF THE INTERNATIONAL STEAM PURIFIER SHOWING A GROUP OF VANES AND THEIR POCKETS

on the other side. Sufficient protection of the alternate scrubbers into the steam passage prevent straight line travel of any of the steam through the purifier compartment.

The tops of the purifying compartments are closed, the scrubber pockets drain into a drip chamber formed by the pocket closure of the purifying compartments. The compartments in an International purifier are made of monel metal and so designed that they will readily pass through manhole openings with the purified steam collecting chamber. The purified steam from the purifier compartment is collected in a cast-iron chamber with flanged tubes, or in some types form the outlet connection to the steam nozzle drum. The castings also are of such size and shape as to readily enter boiler drums through manhole openings.

The lower part of each purifier compartment connects to a water collecting chamber which receives the moisture and impurities. This chamber is entirely separate from the purified steam collecting chamber. Water collecting chambers are provided with pipe connections which join to the main lead or drain and carry off the impurities to a trap. The trap, located outside of the boiler automatically discharge the impurities to a suitable boiler blow-off drain.

Statement by The Paige & Jones Chemical Co.

Each year brings to a close definite accomplishments in the field of boiler water purification. The Paige & Jones Chemical Co. appreciating the limitations of each of the various methods now in use has devoted its research toward a better understanding of the basic factors in recommending the method recognized as the most effective for each problem.

It is appreciated that no single known system can effectively take care of each boiler water problem, hence a manufacturer to be of the greatest help to a purchaser must build within his own organization a complete line of water purifying equipment.

Research has disclosed that the after-effects of a treatment are fully as important as the elimination of scale forming salts in the water.

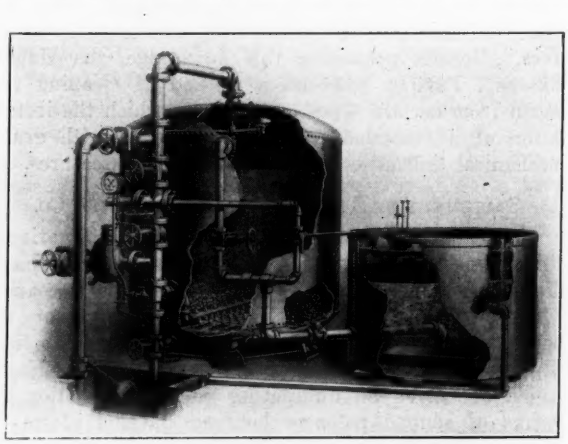
Each method has different spheres of usefulness and if the equipment is used where adaptable, the desired results will be realized. Universal adaptability of a given system is a remote and exploded theory.

The unerring diagnosis of each boiler water problem is of paramount importance and only can such diagnosis be accepted when supported by a technical organization of recognized standing.

Research has revealed that a more careful study of the mineral content of water is essential. Characteristics regarded in the past as of relative unimportance are now recognized determining factors in the selection of suitable equipment. These matters are of such importance that they now come within the realm of scientific study for each problem and unless so considered, recommendations are not only faulty, but futile.

Statement by The Permutit Co.

The method of softening water by zeolites, which was introduced into the United States by the Permutit Co. about 14 yr. ago, has in the past year further



VIEW OF THE IMPROVED TYPE OF PERMUTIT SOFTENER NOW BEING USED, SHOWING DETAILS OF ARRANGEMENT

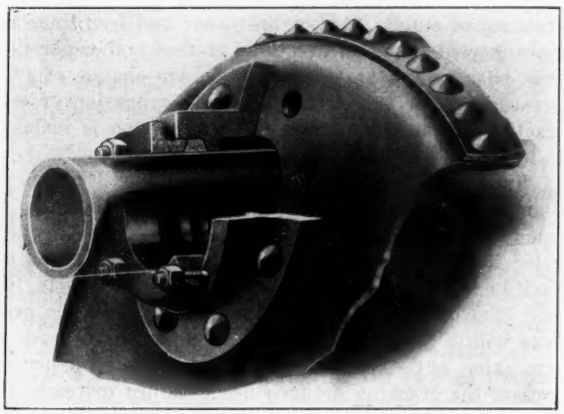
proved its value to steam boiler users in general. Zeolite water softeners are being installed in boiler plants in increasing numbers for the following reasons:

a. The present tendencies of firing such fuels as oil and pulverized coal, and operating boilers up to 300 per cent of manufacturer's rating, etc., emphasize the need of keeping the heat transmission surfaces absolutely free

from deposits. This can only be accomplished by using a feed water absolutely free from scale forming constituents, such as zeolite softened water or distilled water.

b. The softening of water by zeolite is of especial interest in boiler plants because the softening takes place in the cold. This eliminates any loss of heat from the water purification plant itself, or from storage of large quantities of hot water. The water is furthermore in a condition best suited for heat absorption in the heaters. The final heating and deaeration can take place immediately before entering the boiler, thus avoiding all losses of heat and reabsorption of oxygen.

c. It is becoming more generally recognized that the presence of non-incrusting alkalinity in Permutized



STUFFING GLAND PIPING CONNECTIONS USED IN THE HEADS OF ALL PERMUTIT HORIZONTAL FILTER AND SOFTENER SHELLS

water is advantageous for makeup purposes, because there is usually some condenser or other leakage which introduces scale forming constituents into the boilers. This must be taken care of to prevent the formation of scale by adding artificial alkalinity. The Navy, for instance, uses distilled water exclusively and makes it a rule to maintain a certain alkalinity in the boiler saline by the addition of soda ash. Zeolite softened water contains this alkalinity and, therefore, takes care of the usual amount of leakage automatically and without additional cost.

d. Where cooling water is very bad or scarce and is recirculated, it has been found advantageous to Permutize the makeup water to the cooling system. This not only prevents scaling of the condenser tubes, but even if there is condenser leakage, it eliminates the introduction of scale forming constituents into the condensate.

It is due to these facts and the relatively low installation and operating costs, simplicity of operation, and the ability to satisfy varying load requirements that so many boiler plants are adopting the zeolite treatment for softening their makeup water.

The zeolite softener itself is essentially unchanged from the original design. To facilitate the operation of the plant and make it still more fool-proof, improvements have been made from time to time.

An automatic backwash control, shown in illustration has been invented, which permits wide opening of the operating valves without the danger of flushing out the zeolite.

Improvement has also been made in the salt dissolving equipment which permits the use of a cheap, common run-of-mine salt. The brine saturators are now so designed as to combine rapid dissolving of the salt, removal of dirt present in such salt and ready disposal of this dirt from the dissolving tank.

Stuffing gland piping connections to the heads of all horizontal filter and softener shells have been adopted. For large diameter shells where pipes were formerly leaded into a bell-shaped nozzle, the breathing of the heads would cause the lead to creep as the water pressure varied within wide limits. A stuffing-box type of nozzle is now employed as illustrated, which has entirely eliminated this difficulty.

Lime-soda softeners, both hot and cold process, are still manufactured and installed by the company where a partial reduction of the hardness is all that the purchaser desires. Where waters are turbid and require pre-treatment and the carbonate hardness is high, combination plants in which the water is first pretreated by lime and then finished off to zero hardness by zeolite, are also being manufactured and installed.

Statement by Schutte & Koerting Co.

The latest type of feed water evaporator made by us has been termed the recirculating type, as the raw water is picked from the lower end of the shell and pumped back into the top of the evaporator. The shell is designed as a vertical cylinder in order to conserve floor space and to facilitate removal of tube bundles for inspection or repair. The water pumped from the lower part of the shell is delivered to a water box in the upper part of the shell, the bottom of this box being perforated to permit the recirculated water to rain down over the tube bundle. This box has a manhole which is accessible from the outside of the shell.

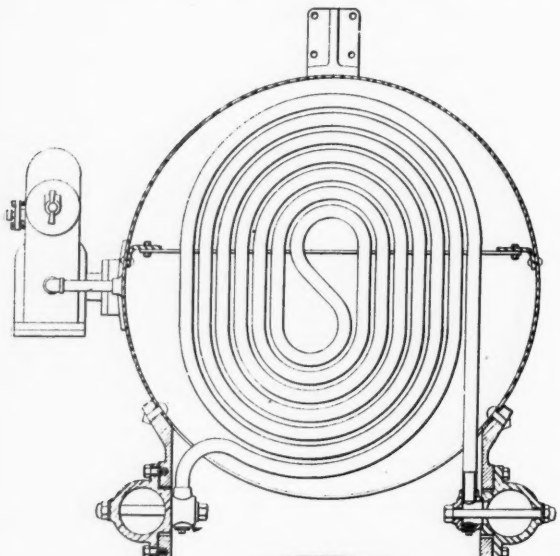
The tube bundle consists of two vertical headers, to which are connected by flanged joints, the flat horizontal spiral evaporator coils. The bundle can be removed as a unit and individual coils can readily be disconnected for repair or replacement. The steam and drain pipes can be disconnected from the tube headers from the outside of the evaporator shell.

The bottom of the evaporator shell is arranged as a scale pocket with blowoff connection, the recirculated water passing around a baffle and through a screen which keeps back scale and other impurities. The upper end of the shell forms the vapor space and in this is arranged a moisture separator of the centrifugal type.

Statement by The Wheeler Condenser & Engineering Co.

Evaporated feed water is coming to be regarded as a necessity if high pressure boilers are to be operated at high rating. The Crawford Avenue Station of the Commonwealth Edison Co., Chicago, one of the first plants to operate at 600 lb. pressure and 750 deg. temperature, is now being equipped with a quadruple effect Wheeler Film Type low pressure evaporator to supplement the zeolite softeners now in operation. Other plants operating at 550 lb. or above which are, or are being, equipped with Wheeler evaporators, are the Philo plant of the Ohio Power Co., the Twin Branch plant of the Indiana & Michigan Electric Co., and the Stanton, Pennsylvania plant of the Exeter Power Co. In the last named plant, the main condensers are of spe-

cial construction to prevent leakage of circulating water into the boiler feed water. To obtain the full effects from evaporators, it is necessary that all the makeup be supplied by the evaporators, and not by leakage of circulating water in the condenser. The Wheeler condensers at Stanton have the tubes rolled in both tube sheets so that leakage at the tube ends is prevented. One tube sheet is floated upon a rubber expansion joint to compensate for temperature changes in the tubes and shell. This system of boiler feed protection, with leakproof condensers and all makeup supplied from evaporators, has been in use for some months at the Trinidad Station of the Texas Public Utilities Co. (boiler pressure, 400 lb. gage). The operating force at this station has reported that there is no condenser leakage detectable with a conductivity meter. Circulating water for the Trinidad Station is taken from the Trinity River, and contains a large percentage of salt, tempo-



CROSS SECTION OF WHEELER CONTRAFLO EVAPORATOR, SHOWING COIL AND COIL COUPLING

rary hardness, and suspended matter. A small percentage of leakage could easily introduce an undesirable quantity of solids into the boiler feed water. It is interesting to note in this connection that Loftus Perkins, who built and operated engines for 600 lb. gage pressure over 50 years ago, employed this system. He employed condensers with the tubes screwed in heavy tube sheets and supplied all makeup from evaporators. It was noted with great astonishment by the British Admiralty Committee on Boilers that Mr. Perkins' boilers operated for years (one boiler investigated was in service 13 years) without burning out or requiring cleaning.

Wheeler evaporators for power plant use have not been changed materially in design during the past year. Film Type evaporators, in which the water level is below the bottom tube and the water is recirculated over the tubes by means of a circulating pump, are used for low pressure installations, and submerged type evaporators are used for high pressure operation.

The film type of evaporator consists essentially of a nest of tubes through which steam passes and over which a continuous rain of liquid falls. The level of water is held below the bottom tubes, whence it is lifted continually by a centrifugal pump to a nozzle over a perforated distributing tray from which it showers down over the tubes, covering each with a film of evaporating liquid. Owing to the hydrostatic head on the heat transmitting surfaces and to the uniform and positive circulation of the liquid, film evaporators show uniformly high heat transmission and can be operated on very low temperature head, fitting in well with power station heat balance when used as makeup evaporators.

Where Wheeler evaporators are used in multiple effect, they are generally arranged for temperature cracking of scale. That is, the vapor and feed lines are so connected that the directions of feed and vapor flow may be reversed, as to cause a sudden change of temperature of the tube. The resulting expansion or contraction of the tube causes the scale which is inelastic to loosen and fall off.

Since a straight tube much less than 2 inches in diameter does not expand and contract sufficiently to remove all scale by temperature cracking the elliptical tube illustrated was designed to facilitate this action in small sized evaporators. This tube acts like two joined coils of the Bourdon gage. When the pressure within a coil of this shape is increased it tends to straighten out. The elliptical cross section further increases the cracking action since pressure increases the cross-sectional area, making the tube more nearly circular. As the weakest part of the scale is the bond between it and the metal, and as the greatest shear is at this point, cracking produces a clean tube.

In the Wheeler submerged tube evaporator the feed regulator is arranged to hold the operating level at about the top of the tube nest, and the circulating pump necessary with the film type is eliminated. Submerged type evaporators for low pressure work are made with ellipticoil tubes and except for the parts needed for film operation are very similar in construction to the ellipticoil film exaporator. The factors determining the number of effects to be used are first, the per cent of make-up required, and the heat balance of the station. If a large heat drop is available between the source of steam for the evaporator and the heater in which it is desired to condense the distillate, a single effect evaporator will generally suffice. If the temperature drop is lower, a multiple effect must be used.

Good Roads Savings

EXPERTS say that careful experiments covering a period of years show that the average motorist will save 2.5 cents a mile by traveling on a smooth instead of a rough road. This is for the factors in running the car and takes no account of the time lost. Assuming that each motorist travels 5000 mi. in a year and that half of it is on rough roads, the twenty million motorists of the country are enduring fifty billion miles of rough going and are paying, annually, $1,250,000,000 for the privilege. That sum would build many miles of concrete pavement so that its investment would seem to be an investment for economy rather than an expensive luxury without financial returns.

Present Status of Economizer Practice

STATEMENT BY BABCOCK & WILCOX CO.

SALES in economizers have been satisfactory throughout the year, though the use of bleeder heating of feed in multiple stages has perhaps narrowed the field for this class of apparatus, the economizer not having a sufficient temperature range in which to function.

A unit consisting of a relatively small amount of boiler heating surface and a relatively large amount of combined boiler and economizer surface, or steaming economizer surface, has recently been placed in service with extremely satisfactory results.

STATEMENT BY THE GREEN FUEL ECONOMIZER CO.

Unfortunately the developments we have under way on new equipment are not far enough advanced to give details out for publication.

STATEMENT BY POWER SPECIALTY CO.

Among other factors, the rate of transfer in any type of heat exchanging apparatus is a function of the rate of mass flow of liquids over the heating surface and is dependent upon their temperature, viscosity and thermal conductivity. With water inside of tubes and flue gases outside, as in an economizer, this transfer may be taken for rates of flow as obtained in common practice as a straight line function of the rate of gas flow according to an equation of the character

$$R = a + bF$$

in which R is the rate of transfer in B.t.u. per hour per square foot per degree mean temperature difference and a and b are constants whose value is determined by experiment. F is the flow of gas in pounds per hour per square foot of gas area.

From this formula it is obvious that greatly increased rates of transfer are obtainable by increasing F. Thus smaller economizers will do the same work and can be purchased at a lower cost when high gas velocities are used. An additional advantage is the elimination of stratified gas flow, forcing all parts of the heating surface to operate at equal efficiencies.

The extended outside surface of the Foster economizer has six times the area of an equal length of the bare 2-in. steel tube on which the surface is built. The construction of the casing at the tube end permits the elements to be spaced on almost any center to center distance desired. It is, therefore, possible to manufacture this economizer either with a restricted gas area to give a high rate of heat transfer, or with a large gas area for operation on natural draft at a relatively low transfer rate.

Draft losses increase roughly as the square of the rate of mass flow of gas and directly as the length of gas passage. The additional power to operate the induced draft fan must be debited against the increased water rise obtained by adopting high rates of flow. The power in kilowatts to produce the draft loss is obtained as follows:

$$\text{Cu ft. gas per min.} = \frac{T}{40} \times \frac{W}{60}$$

in which T is the absolute gas temperature at the fan inlet and W is the pounds of gas per hour passing through the fan.

$$\text{Air hp. of fan} = 0.000158 \times \text{c.f.m.} \times D$$

in which D is the draft loss in inches water gage.

Assuming a constant fan efficiency of 60 per cent and a motor and line efficiency of 85 per cent the kilowatts of fan power required at the switchboard can be obtained in one operation by combining the above and multiplying by 0.746 giving the formula:

$$\text{Kw. of fan power required} = \frac{DWT}{10{,}385{,}000}$$

Experience has conclusively shown that the Foster economizer with 1.5 in. of 3.0 in. water gage draft loss at the normal operating point of the boiler produces the highest rate of return on the investment that can be realized from any economizer installation.

Headers on Foster economizers are made of forged steel as are those of our superheaters, water walls, water backs, etc. The tubes are of steel 2 in. in diameter and covered with cast-iron extended surface. There is no change in previous construction.

Cleaning of the exterior of the economizer is usually effected by steam soot blowers. The quality of the gases and temperature has a great deal to do with the method of cleaning, and water may be used to wash the surfaces in certain economizers. Presumably compressed air would also be satisfactory but it is not possible to make a definite statement embracing all installations because the conditions are not the same and what is most satisfactory in one plant will not necessarily fill the bill in another. In order to secure the best results, a detailed study must be made of the operating situation and that is the only basis upon which this company would attack the problem.

Economizers are located as close as possible to the gas outlet of the boiler. Group economizers are not regarded as favorably as individual economizers because the distance from the boiler always injects the possibility of heat radiation losses and air infiltration. The largest individual economizer in the world is now being put into service at the North Electric Power Station of the City of Amsterdam, Holland, under the direction of Dr. Luloffs.

TESTS OF the fusibility of coal ash and the relation of such tests to the clinkering characteristics of the coal are being conducted at the Pittsburgh Experiment Station of the Bureau of Mines, Department of Commerce. While laboratory methods for determining fusibility of ash have been carefully investigated by the Bureau and standardized, no comprehensive study has hitherto been made as to how accurately such laboratory tests predict clinker trouble in burning coal. Seven different coals having a wide range of ash fusibility were tested for fusibility by the standard method worked out by the Bureau, and two other well-known methods. The coals were studied as to the distribution and composition of the ash-forming constituents, the sulphur content, and fusibility of ash. Firing tests were made on the same coals in a special hand-fired furnace developed by the Bureau engineers. The results of the fusibility tests were generally found to be indicative of the clinkering trouble that was experienced in burning the coals. The work is being continued on other coals.

STEAM GENERATING EQUIPMENT

Developments in Boiler Construction

STATEMENT BY BABCOCK & WILCOX CO.

TRENDS TOWARD the use of higher pressures noticeable in the past few years have continued through the year—not so much in actual increase in pressure as in the greater proportion of total installations using these increased pressures. There are installed, or are on order, for twelve different stations Babcock & Wilcox boilers built for 650 lb., or over, totaling more than 1,000,000 square feet of heating surface. The tendency to the use of higher pressures is also extending to the industrial field.

Three 1200-lb. Babcock & Wilcox boilers and one 1390-lb. Stirling type boiler, built by this company, are all in satisfactory operation and an order has just been placed with the Company for two additional Babcock & Wilcox units to be built for a working pressure of 1400 lb. It is gratifying to the Company that in building these boilers for such high pressures it has not been necessary to depart from the general features of design standard for lower pressures. The reheat units have given satisfactory service and in operation have shown a greater degree of flexibility under varying load conditions than was generally anticipated.

STATEMENT BY THE BIGELOW CO.

We have developed Bigelow-Hornsby boiler construction suitable for pressures up to 600 lb. The drawing shows the side elevation of a boiler of high-pressure design which is now under construction. This is a stoker-fired installation with air preheaters and a front water wall.

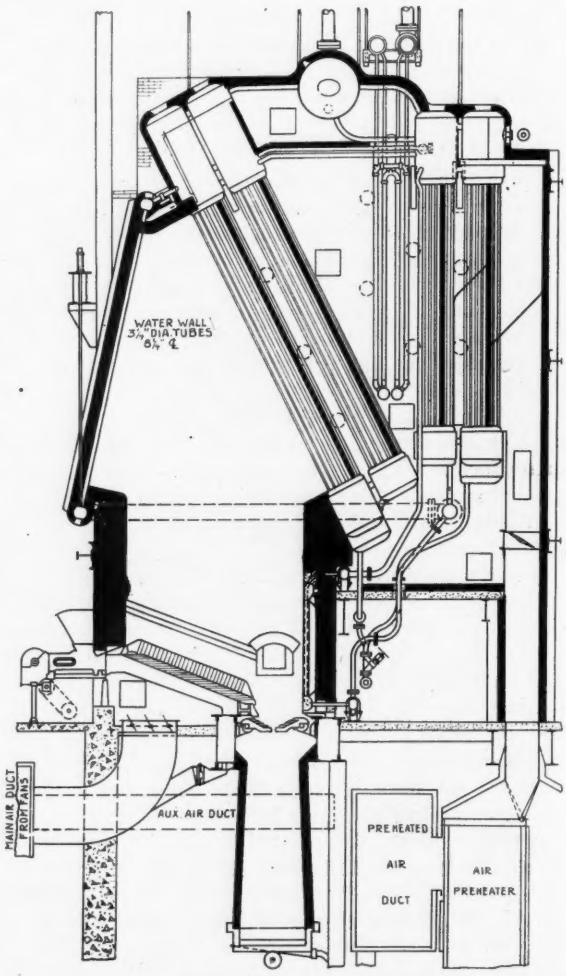
STATEMENT BY THE CASEY-HEDGES CO.

We have not placed any new designs on the market in the past year but we have devoted our efforts to adjusting our proven designs to the advanced conditions existing in the power plant field, not only as to firing conditions but as to high pressure.

Two of our designs, that is, the Multipass and the Semi-Vertical can now be made up to pressures as high as 600 lb., although the highest that we have yet had occasion to build has been 425 lb.

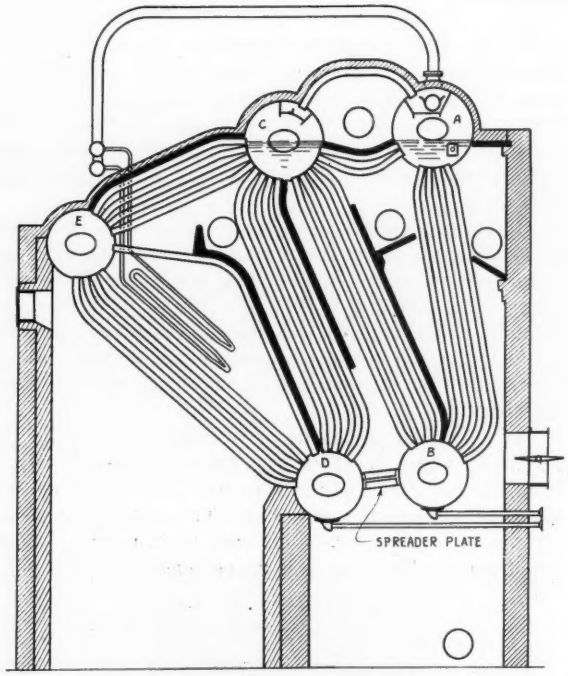
In both of these designs, one of the special features is the arrangement of the front baffle which provides ample space for a superheater in front of the baffle without placing the superheater elements between the tubes, which is objectionable under certain conditions, and without the loss of any effectiveness of the heating surface in the front bank of tubes.

With reference to the Multipass design, shown in cross-section, experiments which we have just completed have proven our claim for a double-circulating system in this boiler. The boiler is complete in two sections, one front section and one back section, and these two sections are connected together by Drum C. In each section there is a positive independent circulation, the water is fed into drum A, goes to drum B, from drum B to C and from C to A. This constitutes the first system. The second system is C to D to E to C.



A RECENT HIGH-PRESSURE BIGELOW-HORNSBY BOILER INSTALLATION WITH PREHEATERS AND WATER WALLS

For making these experiments a working model was used with glass drum heads and several glass tubes. For supplying heat two electric elements of 600 watts were placed in the furnace. The arrangement developed several novel features. It was found that the variation in the velocity of circulation in the front section did not cover a wide range, but the velocity of circulation in the rear section varied largely with changes of application of heat. By increasing the heat from the fur-



SECTION OF THE CASEY-HEDGES CO. MULTIPASS BOILER WITH TWO SEPARATE CIRCULATING SYSTEMS

nace, or increasing the air, the velocity of circulation in the back section was increased to a much higher ratio than the first section. This bears out our claim that with changing of the rating and firing conditions, the range of the flue gas temperature is much less than with other conventional types of boiler. Actual experience and observation of the working model has proven our claim that all precipitates accumulate in the rear bottom drum and that unless the water conditions are extremely bad, no scale whatever will accumulate in the front section of the boiler.

Statement by The Heine Boiler Co.

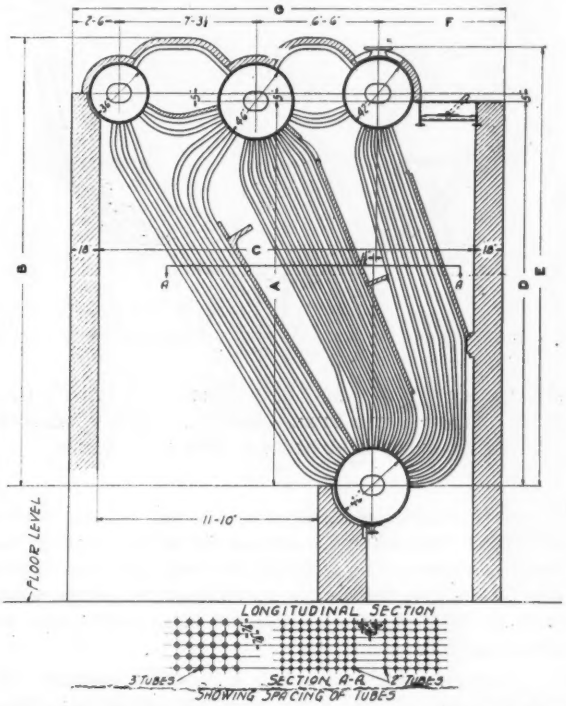
We have developed a new line of bent tube boilers especially for the higher pressures. This line has been called our VX Type. Our standard straight tube boiler designs lend themselves very well to higher pressures, but our standard V type has certain features making it costly to complete for pressures much in excess of 325 lb. The shell plate thickness becomes excessive, and in addition to the difficulties this affords in fabrication, it is also considered undesirable by some engineers to have very thick plates in the fire zone.

Our standard VX design is shown in Fig. 1 with the tubes arranged for the superheater among the tubes in the front bank. As will be seen from the tube layout detail this arrangement consists of six 3-in. tubes in the front bank, nine 2-in. in the middle and six 2-in. in the rear bank. Water circulators and steam conductors connecting the three upper drums are 3 in. in diameter. Tube spacing going across the boilers is entirely different from our standard V type or any other bent tube type now on the market. The tubes are all spaced along equal center distances, 7⅛ in. for all 3-in. tubes, 4¾ in. for the 2-in. tubes used in the middle and rear banks.

This arrangement permits the withdrawal of any 3-in. tube on either side of the row of tubes it happens to be in. Each side of the tube is made equally effective because the gas streams passing along each side are equal and this is retained throughout the middle and rear banks.

Tubes in the rear bank may be passed forward between tube rows of this bank, the middle bank and front bank without taking out any front tube. This tube spacing is the result of studies of the problem which indicated that it would be necessary to increase the tube spacing and reduce the tube diameters in order to increase the drum ligament efficiency. High-pressure boilers must also be more efficient heat absorbers in order to have a high thermal efficiency, and all of these points were taken into consideration in making up final designs for this new type.

Details are varied somewhat to meet different furnace, baffling and superheater arrangements and any of these boilers may be equipped with the new VX type



CROSS-SECTION OF SETTING AND SPACING OF TUBES IN THE NEW HEINE BOILER CO. TYPE VX, HIGH-PRESSURE, BENT TUBE BOILER

integral economizer. With this arrangement the rear bank of boiler tubes is bent so that the bends come at the ends and the economizer section is placed so that the tubes are parallel to this bank. This accomplishes three things. First, the gas passages are uniform throughout the economizer; second, the baffles can be held in place without special clamps; third, the gas exhaust can be placed behind the upper drum so that the dimensions of the unit can be kept down to the absolute minimum.

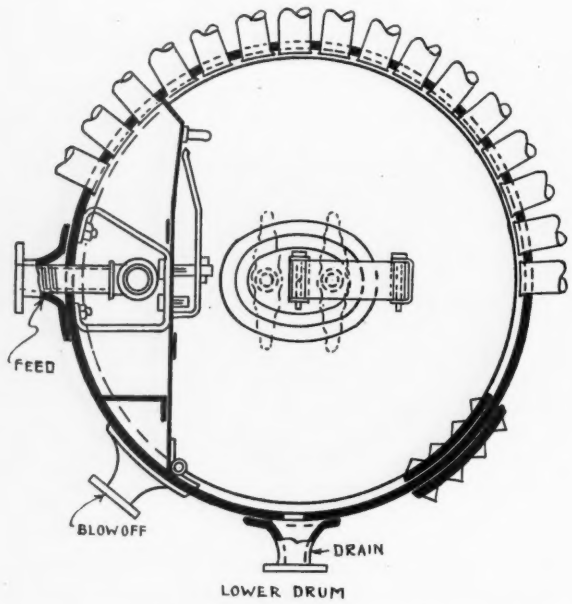
Statement by Kingsford Foundry & Machine Works

We have not made any radical changes in our boilers, but of course, are prepared to take care of higher pressures by heavier tubes and drums. As yet we have

not manufactured reheat boilers or superheaters, consequently we cannot give you any information on this particular material.

STATEMENT BY LADD WATER TUBE BOILER CO.

We have found that 2-in. plate is as heavy as we wish to bend and rivet at the present time. Above this thickness we are using forged drums and at the present time have 32 drums either constructed or in the course



ARRANGEMENT OF FEED-WATER BAFFLE IN THE LOWER DRUM OF LADD WATER TUBE BOILER CO. BOILER IS DESIGNED TO COLLECT IMPURITIES IN THE FEED WATER

of construction. Heads are made as part of the forging and necked in after the remainder of the forging has been machined. No welding is used, and the nozzles are fastened to the drums by rivets or by studs, either with or without gaskets, and the tubes rolled into the drums and flanges.

Pressures range up to 825 lb. working pressure, and special gage glasses and other apparatus have been adopted.

We have built no reheat boilers.

From the sketch it will be noted that water is fed into a chamber in the lower drum under a baffle which segregates several rows of tubes. This directs the feed water slowly upward in these tubes in such a manner as to give maximum contact of the incoming water with gases in the last pass. This provides a preheater effect which removes a large portion of the impurities in the water and allows them to be blown off from the bottom of the feed box. Scale-forming impurities are minimized in the hotter section of the heating surface and it has been demonstrated in practice that Ladd boilers, with impure water, operate for a considerably longer period between cleanings than is usual in other types.

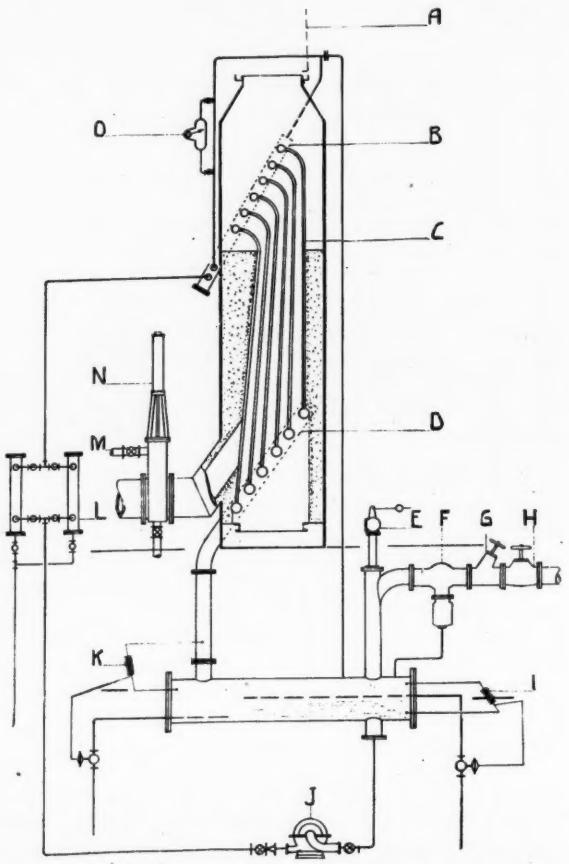
By hinging the feed box at the bottom and holding it in place by wedges, it is held tight when closed, yet is easily accessible for inspection or tube renewals.

STATEMENT BY THE LAMONT CORP.

In the LaMont steam generator the laws of heat transfer have been combined and carried forward to a point which actually constitutes a "new way of making steam." It has been in practical use for over a year and is a striking example of the possibilities of light weight, small space demand, perfect safety and high efficiency.

Operation depends upon the injection of a small but oversufficient amount of water pumped through the ⅝-in. tube in such a manner that the water strikes the sides of the tube and is held in a film in the interior of the thin metal wall, by adhesion of the water particles to the metal and cohesion to each other, creating a hollow center for the passage of the steam thrown from the film.

As only part of the water is turned into steam the remaining water, together with the steam formed, issues from the lower end of the tube and passes to a collecting pot thence to the separator. The steam then passes through the nonreturn stop valve to the main steam line for use. This steam is 99 per cent plus dry.



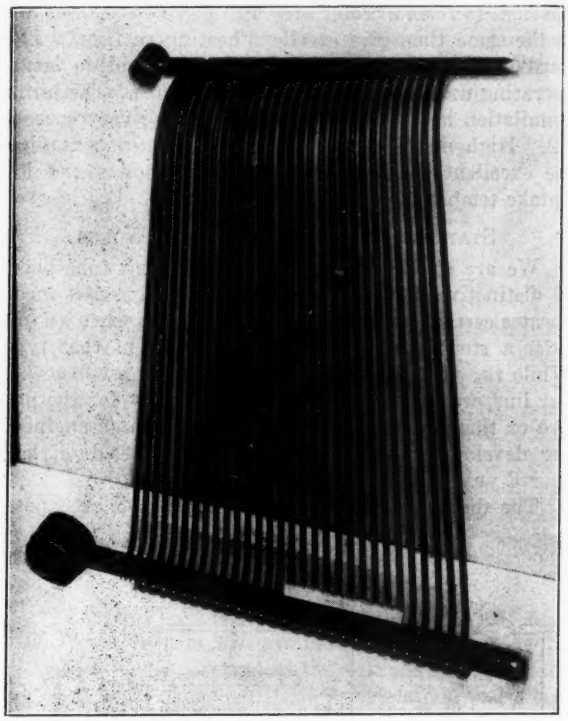
THE ARRANGEMENT OF THE LA MONT STEAM GENERATOR IS SHOWN BY THIS DIAGRAMMATIC DRAWING

Unevaporated water which has been heated leaves the separator and returns to the water level pots carrying with it any carbonates and sulphates or other scale-forming matter, which may have been precipitated in the passage to the heating surface. This unevaporated hot water mixes with the cold feed water in the water

level pot, there precipitating the carbonate and sulphate outside of the tubes. This mixture of hot water from the tubes and cool feed water, together with any remaining scale-forming matter, is picked up by the pump to be passed through the duplex screen and returned by the return circuit system to the tops of the tubes where it is injected as described above.

By blowing down the few gallons of water in the screen, scale-forming material is quickly removed and the injection jet opening at the top of each tube is blown back by a jet of steam from each one of the boiler tubes to clear all openings of any possible collection of foreign matter.

Close spacing of the tube heating surface gives high gas velocity, while the easy angle of entrance of gases and the straight up-flow results in clean outside surfaces and effective heat transfer with a minimum of draft loss. A diagrammatic arrangement drawing is



TYPICAL HEADER AND TUBE ASSEMBLY OF THE LA MONT STEAM GENERATOR SHOWING SMALL TUBES USED

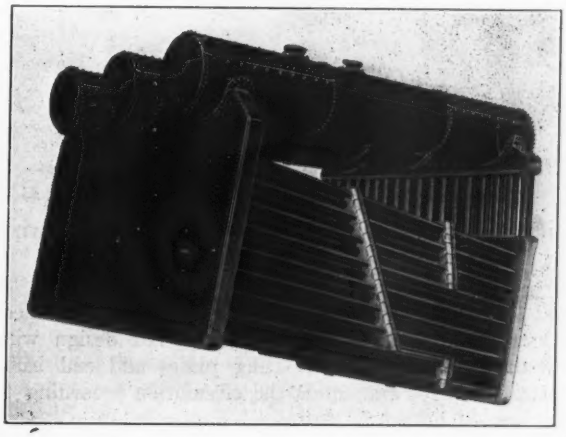
shown and as can be seen the single gas passage is tapered toward the outlet to maintain the proper velocity of the cooling gases as they near the outlet. The photograph shows an actual tube and header assembly made up of tubes shorter than the standard 25 ft. 6 in. length, for convenience.

Close adherence to fundamental laws of heat transfer results in a very high rate of boiler operation. The method is obviously entirely different from the type of steam generators in which the steam must break through the water, carrying much of the water with it. The LaMont steam generator is not a "Flash" boiler by any interpretation as the water is introduced through at the coolest end of the tube, absorbing an increasing amount of heat as it flows downward and because more water is injected into the top of each tube than can be evaporated.

It is ideally adapted to the high pressures now increasingly in demand and for central power stations, public utilities and industrial power plants, where its high efficiency, safety and low housing costs make its features especially attractive.

STATEMENT BY MURRAY IRON WORKS CO.

We are completing a 300-lb. boiler for the city of Fremont, Nebraska. This is of the same type as illustrated herewith, a long drum straight tube type with a regular fire box steel front header directly riveted to



TYPE OF 300-LB. MURRAY IRON WORKS CO. BOILER NOW UNDER CONSTRUCTION FOR THE CITY OF FREMONT, NEBR.

the drums with the rear header of fire box steel made in two sections connected together with a double row of vertical tubes. Steam drums are 36 in. in diameter, and the tubes of 3½ in. seamless steel 18 in. long placed in one bank.

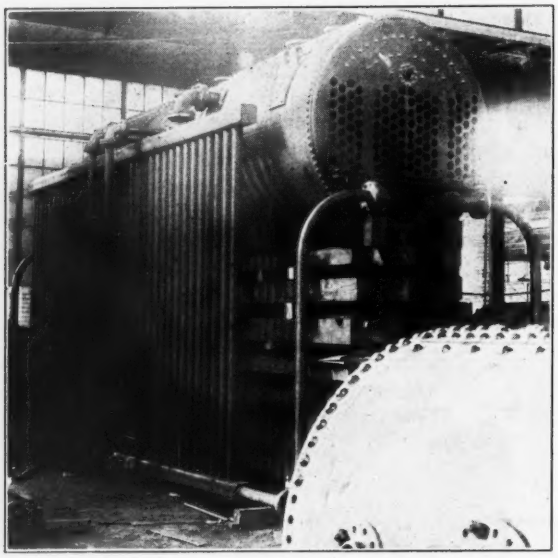
Feed water inlets are located 1½ inches in front of the drum heads with blowoffs in rear drum heads and back water legs. Vertical bafflings are used with the fourth row of tubes omitted to facilitate the installation of a short section of horizontal baffle in order to place practically all of the lower three rows of tubes in the first pass.

So far these boilers have all been stoker fired and in several cases were provided with water-cooled walls. An installation of this type, with stokers, superheaters and water-cooled walls has been made at the plant of the Iowa Southern Utilities Company at Centerville, Ia., this fall and is now in service. It is one of the most modern installations in this state and although complete test data are not yet available, we hope to have full particulars soon.

STATEMENT BY NUWAY BOILER & ENG. CO.

We have recently perfected the Nuway water wall boiler designed so that high furnace temperatures and boiler ratings could be obtained without the objectionable high maintenance costs on brick work. Furthermore, the maximum absorption of radiant heat from the furnace is obtained and radiation loss is cut to a minimum.

Construction of the boiler is such as to maintain the same circulation which has proven so successful in the



SHOP VIEW OF THE NUWAY WATER WALL BOILER SHOWING THE CONSTRUCTION AND METHOD OF FEEDING

standard Nuway Super-Circulation boiler, the tube sheet construction being of an open staggered design with circulating channels, circulating plates and end baffle plates to direct and guide the circulation according to the laws of nature.

Water is driven up between the heated tubes and finds the path of least resistance between the circulating spaces and plates, which are kept away from the tubes so that there is no heat transferred through them. Circulation of the water through these paths of least resistance is caused entirely by the different densities of hot and cold water and, the circulation being at approximately right angles to the path of the gases, becomes more rapid as boiler rating is increased. Moisture content of the steam at over-ratings rarely exceeds 1 per cent and the uptake temperatures are phenomenally low.

Forged steel headers feed the water walls, these headers being supplied in turn from the shell of the boiler proper at a point near the base of the circulating channels. This arrangement is clearly indicated in the photograph.

Steam and water are returned to the shell above the water line. Water walls are backed with ordinary tile and 3 in. of nonpareil insulating blocks which are encased in a steel casing.

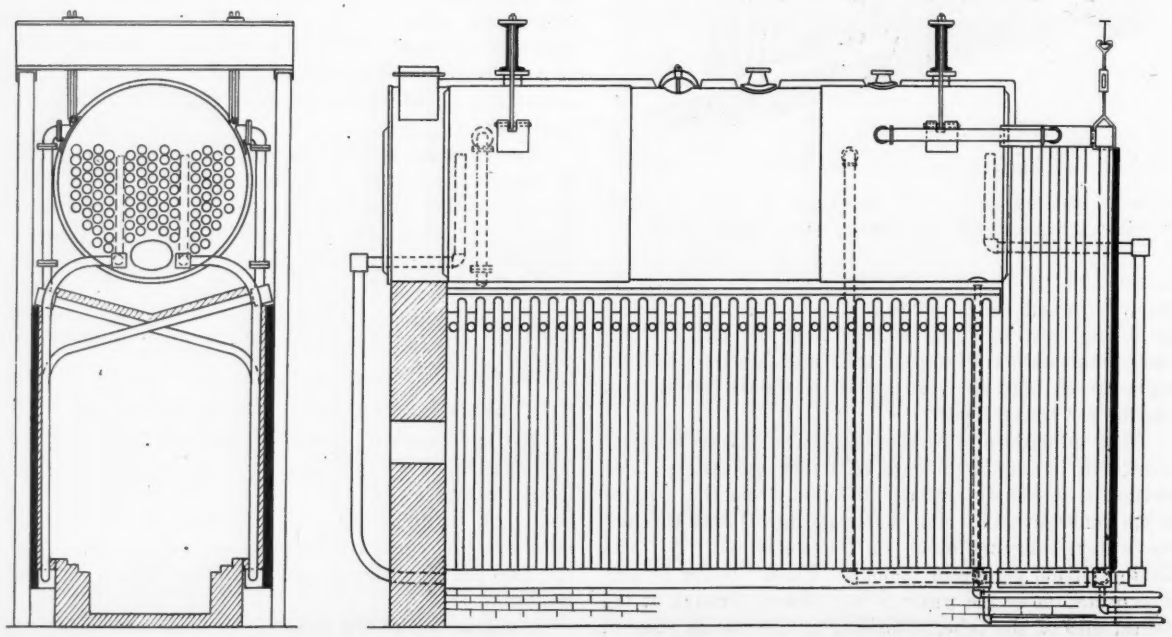
Special rear arch construction was necessary to prevent air infiltration at this point. I-beams were placed from the regular boiler suspension members to the rear wall with the usual flat arch suspension sprung across these members.

For pressures of over 150 lb. a special construction, whereby the headers are fed from the shell proper, as shown in the drawing, and the tubes crossed underneath the shell to form a water screen to protect the walls and at the same time give excellent heating surfaces. This construction enables us to enlarge our field to larger operating units and high working pressures. The initial installation has been made and is proving very successful. High efficiencies are being maintained because of the excellent circulation, low radiation losses and low uptake temperatures obtained.

Statement by The Union Iron Works

We are coming out with a vertical bent tube boiler of distinctive features and patented design that incorporates certain points of merit making this what we consider a step in advance in boiler design of that type. While the vertical bent tube boiler is somewhat new in our line, we having built these boilers only for the past two or three years, the new design represents engineering development work that has been carried on here over 3 yr.

The distinctive features are that the boiler exposes



SPECIAL CONSTRUCTION OF NUWAY WATER WALL BOILER FOR 150 LB. AND OVER WITH SCREEN BELOW SHELL

almost 100 per cent more effective heating surface to the direct action of radiant heat, requires less floor space and head room per horsepower, very much less brick work in its setting, and other features that have been developed from past experience with boilers of this kind.

Most of the development work in boilers has been done by the boiler manufacturers with central station engineers, and progress in the development of boilers and settings in this field has been great in the last 5 or 10 yr. This applies particularly to larger boilers and higher pressures than found in industrial power plants, and while that experience reflects certain improvements to the industrial power field as well, many of the central station refinements in boiler settings, such as economizers, air preheaters, water-cooled furnace walls, and other details are hardly justified in many industrial plants because of the high investment in small units. The Union Iron Works has paid particular attention to developing water tube boilers of highest efficiency and lowest maintenance, without the aforementioned refinements, particularly suited for the average industrial power plant where the boiler room is not run on the extremely high engineering or possibly laboratory engineering standards found in central station service.

Recent Superheater Developments

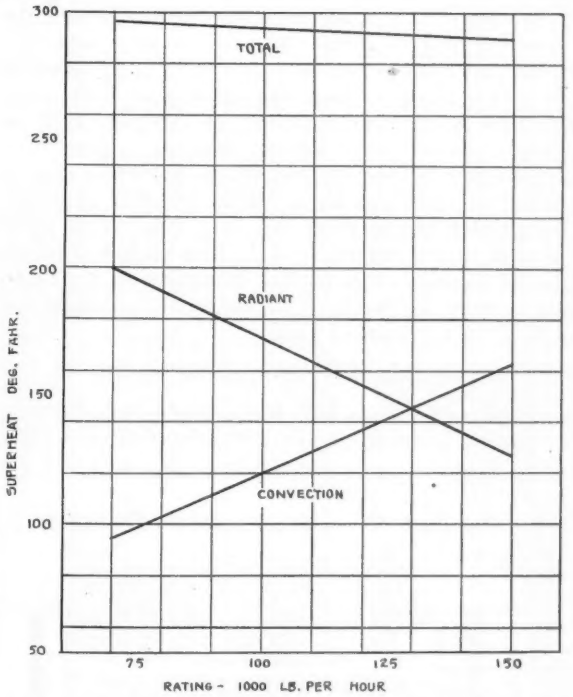
STATEMENT BY BABCOCK & WILCOX CO.

APPARENTLY the tendency in central station practice as to ultimate steam temperatures is toward those of from 700 to 750 deg. F., though higher temperatures are reported from abroad. Industrial plants too are using higher steam temperatures though not as high as central stations. The Babcock & Wilcox Co. is ready to offer superheaters for ultimate steam temperatures up to 900 deg. F., using in that portion of the superheater subjected to the highest internal temperature special heat resisting alloy tubes.

STATEMENT BY THE POWER SPECIALTY CO.

Our superheaters are available for any location in the boilers. When located in the furnaces of the boiler they are known as radiant heat superheaters, and when located among the banks of the boiler tubes or at the top of the tubes and below the drum or circulating tubes are usually known as convection superheaters. When a convection superheater is piped with a radiant heat superheater, the construction is known to us as a combination superheater, although some of the engineering fraternities use the word compound superheater. A combination superheater has a very important characteristic illustrated graphically below which shows the results obtained from a combination superheater installed in an 1850-hp. cross drum boiler with chain grate stokers.

Convection superheaters have a very positive action towards increasing the superheat when the boiler is pushed above its normal rating, or when the furnace conditions are not at the point of high efficiency. Radiant heat superheaters have the opposite characteristic. The superheat from them drops off as the furnace conditions diverge from good performance, or when the boiler



SUPERHEAT FROM A POWER SPECIALTY CO. COMBINATION SUPERHEATER GIVES AN ALMOST CONSTANT TEMPERATURE OVER A WIDE RANGE OF LOAD

is pushed above normal. When combined in proper proportions the action of one of these superheaters will offset the action of the other, thus producing a virtually fixed superheater for wide range of boiler ratings. Thus the power plant engineer can specify maximum steam temperature for his turbine at normal rating, and also supply not more than the same temperature at a high overload. This one will immediately recognize as another step in advance since the economy can be held at a high point under widely varying loads.

Tubes vary in connection with the requirements, but in the majority of cases are limited to two and four-inch tubing of the highest character seamless steel, specially annealed. The extended surface is of a special grade cast iron developed after some twenty years of experimenting. Radiant heat superheater elements are made of forged steel with special forging machinery, as are also the steel return headers. Sometimes whole walls of a furnace are built of forged radiant superheater elements; possibly such a subject should be treated under the general head of furnace walls, since that is what they actually form, although, of course, they must properly come under the heading of superheaters as well.

Headers are of forged steel, carefully machined for tube joints connected with the Van Stone or other approved type and the ends are closed, either by fire-welding or spinning over the ends of the header.

Cleaning of the external surfaces is usually accomplished by means of steam soot blower elements. Internal cleaning is usually considered unnecessary, and the need of it taken as an indication of improper operation. Flooding of superheaters has never been advocated by the Power Specialty Company, and most of the manufacturers now also advise against it.

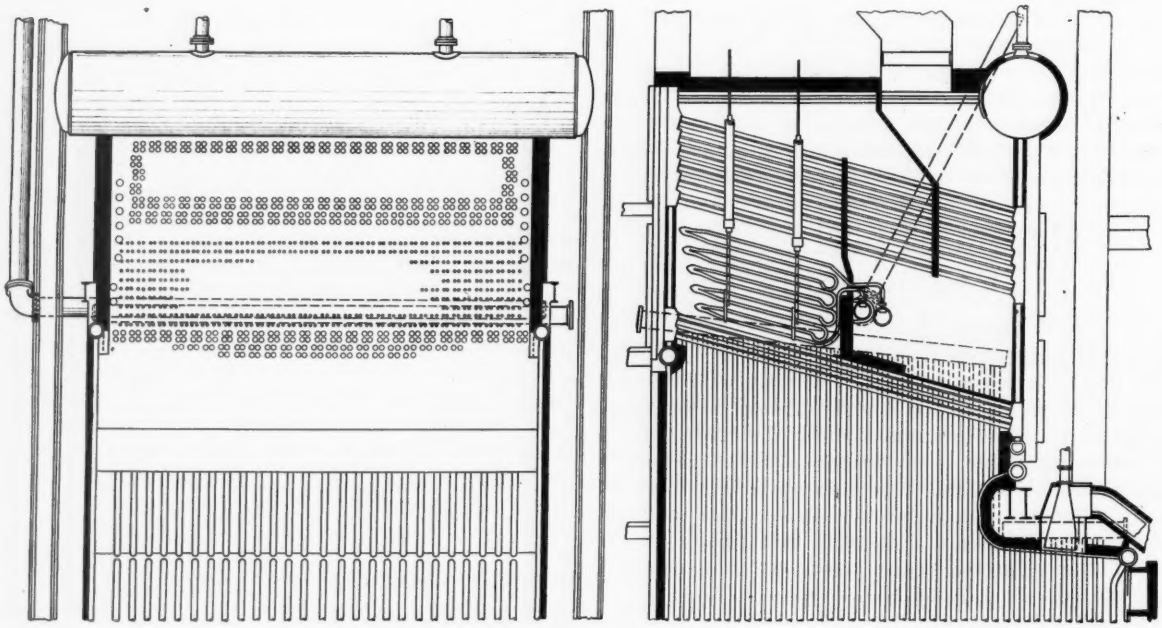
We note that you suggest a statement regarding the "proportioning of surface to boiler heating surface." In the past this has been done in regard to economizers, but we are under the impression that none of the more able superheater manufacturers can recognize such an attitude. Superheaters are not designed in proportion of the boiler heating surface, but to produce a specific amount of superheat for a definite quantity of steam. The amount of superheat will vary from 10 to many hundred degrees regardless of the heat surface of boiler, and we therefore believe that discussion of a proportion between the two is so misleading that it ought not to be given a prominent place.

STATEMENT BY THE SUPERHEATER CO.

Tendencies toward high temperatures and pressures were more prevalent in the past year than any other year previous, with hardly a power plant of any considerable size put in operation with a pressure under 400 lb. Practically all new stations above 60,000 kw. are using 700 deg. Even extensions to old power plants operated at lower pressures were in most cases designed for high pressures and temperatures. A few years ago this company made the first installation of inter-deck superheaters, or a superheater located between the decks of a horizontal water tube boiler. It was at the Hell Gate station where the superheater was located above the sixth tube. This installation has proven a success, and since then other manufacturers are placing the superheater in this location.

As the superheat required in most installations is gradually increasing, and there are a number of installations operating at 750 deg. final temperature, the superheater is being located, instead of six tubes from the furnace, four, and in some cases even less. Due to the development in water cooled walls, which decreases the furnace temperature and also the temperature of the gases passing through the superheater provision had to be made to get the higher temperature. A novel arrangement of boiler tubes in connection with the superheater to take care of the cooling action of the water walls has been used by this company for six boilers, each of about 1600 hp. installed at the new East River Station of the New York Edison Company. They have four 3-in. tubes below the superheater in the center of the boiler. This number is reduced gradually to three, and then to two tubes on each side of the boiler, the arrangement being clearly shown in the boiler section.

With this arrangement of tubes in the lower bank of the water tube boiler, with water cooled furnace walls, not only is the temperature of the gases uniform over all superheater elements, but the efficiency of the boiler is favorably affected. It is a well known fact that the gas velocity is greater in the center of the furnace than at its side. Reduced resistance to the gas flow by eliminating some tubes at the side of the furnace equalizes the flow of gases over the entire width of the furnace.



BOILER TUBE AND SUPERHEATER CO. SUPERHEATER ARRANGEMENT AT THE NEW EAST RIVER STATION DESIGNED TO GIVE EQUAL GAS VELOCITY ACROSS THE BOILER

In cases where no space is available for the inter-deck superheater, a radiant type superheater can be applied, that is, the superheater located directly in the furnace. In order, however, to protect the elements from the direct action of the flame, a new and successful arrangement has been applied, by locating water walls ahead of the superheater. This arrangement has been applied in the Ford Motor Co.'s Fordson Plant, formerly called the River Rouge plant.

With the steadily increasing high superheat and high temperatures, higher velocity of the steam is essential, also in order to make the tubes safe against the high pressures, smaller sized tubing is being used. The superheaters in connection with newly developed steam generators are mostly 1⅝ in. O.D., between No. 9 and No. 6 B.W.G., depending upon the steam pressure.

For temperatures up to 900 deg. we are using standard open hearth seamless steel tubing with a low carbon content. For temperatures of 1000 deg. or higher, the use of extra heat-resisting metal is advisable.

For headers we use open hearth steel, the joints between the units or headers are the well known ball clamp joints which have proven very successful, particularly for higher pressures and temperatures. Superheaters built by this company are self-cleaning, we apply high steam velocity which keeps any solid matter in suspension and carries it along through the superheater.

No flooding is being used. It has long been proven that flooding is rather a menace than a protection, particularly where boilers are often shut down and put on the line again. If the superheater is flooded, the water, while evaporating, leaves a scale inside the tubes, which diminishes the protection of the metal by the steam, and also decreases its capacity for heat transmission.

There is no direct proportion of superheating surface to boiler heating surface, and every case must be figured individually in accordance with the amount of steam to be superheated, the amount of gases available, the temperature difference between the gases and the steam, the velocity of both the gases and the steam, the size of tubing used, etc. How the relation between the boiler and superheater surface varies can be seen from the following examples.

We have a superheater for one modern steam generator, high pressure and high superheat, where the water heating surface is 3346 sq. ft. while the superheating surface is 3580 sq. ft., 108 per cent of the boiler heating surface.

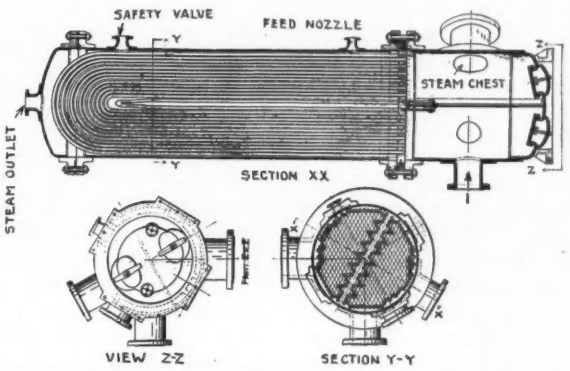
Again we have a number of superheaters with comparatively low superheat, where the superheater, located in the furnace, is only 1½ per cent of the boiler heating surface. Particularly with the latest developments in boilers with large surfaces absorbing heat by radiation, the high superheat required and the various types of boilers, the relation between the boiler and superheater vary so widely that no certain rules or standards can be developed.

High initial steam temperature tends to produce a satisfactory reduction in condensation in the lower stages of the turbine. Steam temperatures are, however, limited by the reduction in strength of the metal at the higher temperatures. Investigations are being conducted in order to determine materials which will stand the higher temperatures. The passing year did not bring, however, any further important development in this direction.

If dry steam is desired throughout the range of expansion in the turbine, it is necessary to resort to reheating for increasing the temperature of the steam after it has passed through a part of the turbine. Some of the large power plants operating with high pressures have already resorted to reheating, accomplished in special secondary superheaters installed in the boiler setting and receiving their heat from the boiler flue gases. In this case the steam has to be carried from the turbine back to the boiler house and again to the turbine. This involves considerable complication and rather large pipe lines, because of the comparatively low pressure of steam to be reheated.

It was recognized that in order to make reheating worth while it would be necessary to find means to reheat the steam at or near the turbine. The passing year has brought out a design which accomplished this. The Commonwealth Edison Company of Chicago has ordered an Elesco reheater for their 90,000-kw. No. 5 units of the Crawford Ave. Station, where the temperature of the steam is increased 100 to 200 deg. before entering the low pressure turbine. Reheating is accomplished by means of high pressure live steam.

In designing extensions to existing plants advantage was often taken of recent advances in steam temperatures and pressures and, by using a desuperheater and reducing valves in the line between the new and old sections, an emergency connection is provided so that the high pressure and high temperature boilers can supply steam for the low pressure turbine. A new type of desuperheater that reduces the temperature of superheated steam without bringing it in contact with the cooling water was introduced during the year. Water at boiler



A NEW TYPE SUPERHEATER CO. DESUPERHEATER INSTALLED TO TIE TOGETHER THE OLD AND NEW SECTION OF THE HUDSON AVENUE STATION

pressure and temperature is used. The heat absorbed from the superheated steam evaporates a part of the cooling water and the steam is returned to the boiler.

An Elesco desuperheater, as shown in cross-section and based on this principle, was installed at the Hudson Ave. Station of the Brooklyn Edison Company, where a new 80-000-kw. turbine, supplied by four 400-lb. pressure boilers, was installed. Besides the desuperheater the steam also passes through reducing valves to lower the pressure from 400 to 280 lb. and in emergency cases the steam from the new boilers, generated at 400 lb. pressure and 725 deg., can be used in the low pressure turbines at 280 lb. pressure and 630 deg.

Ice for Bending Tubing

THE UNITED STATES Bureau of Standards has recently found that, in making coils or spirals of small-diameter brass or copper tubing, ice assists satisfactorily. The tube to be bent is first filled with water which is then frozen by being packed in salt and ice. After freezing, the tube, filled with ice, is bent into the desired shape, then the ice melts and runs out, leaving the tube clean, shapely and empty.

SAFETY IS cheap at any price but it costs only a thought, remarks the National Safety Council.

TURBINES AND AUXILIARIES

Developments in Steam Turbine Construction

STATEMENT BY ALLIS-CHALMERS MFG. CO.

THERE HAVE BEEN no orders received for turbo-alternators of exceptional characteristics. A 50,000-kw. generator is nearing completion, with the prospect that it will be installed and running in a few months.

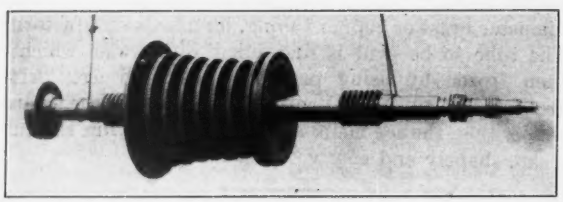
Numerous orders were received during the year for waterwheel driven alternators, notable among which are two 22,000-kw. vertical units and one 18,000-kw. vertical unit. Among others are three 7000-kv.a., two 5000-kv.a. and one 3000-kv.a. vertical machines and three 3750-kv.a. horizontal units. The last three constitute a repeat order.

STATEMENT BY ELLIOTT COMPANY

Several years ago we undertook the development of a line of turbines which would be highly standardized by parts of elements and which would permit building what might be termed special machines (to meet widely varying conditions) from these standardized elements. During the past year this development has been largely extended so that now machines individually suitable for extreme conditions can be built in sizes up to 5000 kw.

For ratings 300 kw. to 5000 kw., the number of stages varies from 7 to 15—all of the impulse type. Generally, the first stage is of the two row velocity compounded type and the others are all single row. Frequently, however, the conditions to be met demand that all stages be of the single row type. The blading is always drop forged and the material used may be either nickel steel or stainless steel, depending upon the conditions to be met. The illustration shows this construction as incorporated in the rotor of an 8-stage, 3000-kw. non-condensing unit.

Automatic bleeding of relatively large but varying quantities of steam for industrial or heating purposes can be accomplished from either one or two stages—that is, either single or double bleeders. The fully automatic bleeder mechanisms employed are patented and have proved highly successful in service. Bleeder pressures as high as 150 lb. gage can be taken care of satisfactorily.



ROTOR OF 8-STAGE, 3000-KW., NON-CONDENSING ELLIOTT-KERR TURBINE

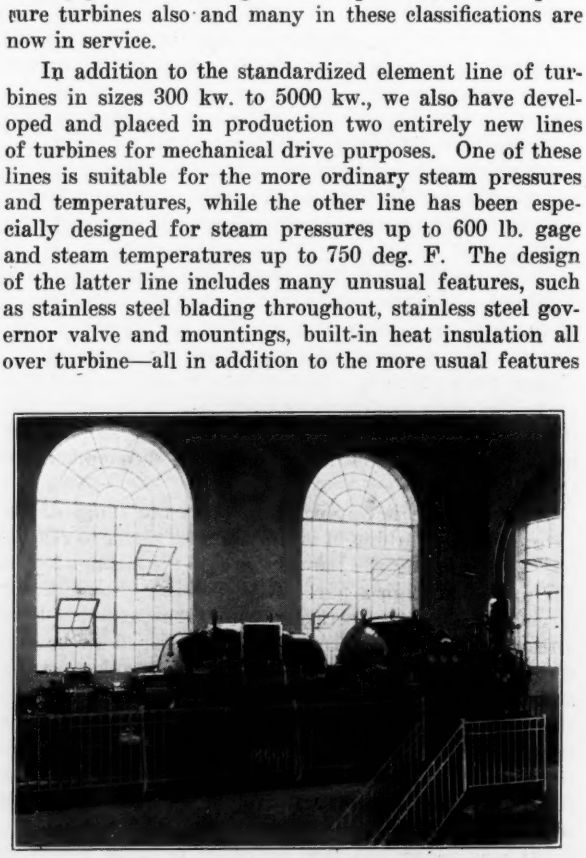
Governing is by means of an improved design centrifugal flyball governor operating the valve system through a hydraulic relay, either single or double relays being employed as required. Excellent part load water rate performance, together with overload or bleeding capacity, is obtained by means of a series of governor operated auxiliary control valves.

Over-speed governing is taken care of by means of a spring loaded centrifugal governor of the pin type located in the main turbine shaft and operating (through a steam relay) a quick closing throttle valve and, when required, vacuum breaker and bleeder non-return valves.

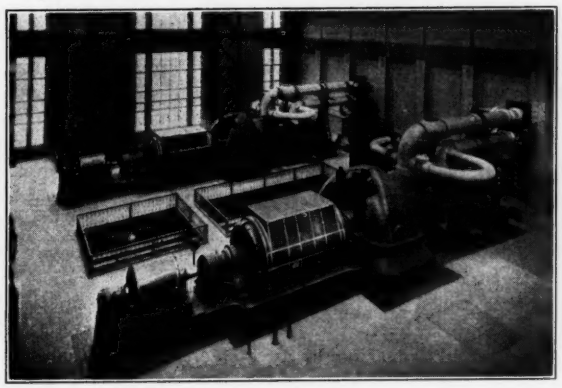
These turbines, being of the impulse type, have practically no end thrust over the whole operating range and the thrust bearing problem is, therefore, a simple one. A Kingsbury thrust bearing of liberal proportions is nevertheless supplied to locate the rotor correctly and guard against any thrust which might arise in emergencies.

Our method of standardizing elements of turbines readily permits building of mixed pressure and low pressure turbines also and many in these classifications are now in service.

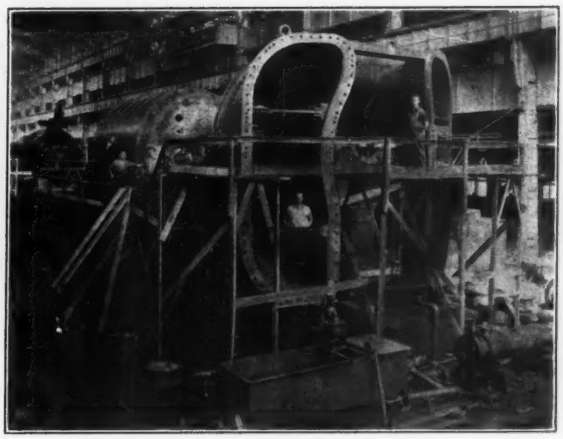
In addition to the standardized element line of turbines in sizes 300 kw. to 5000 kw., we also have developed and placed in production two entirely new lines of turbines for mechanical drive purposes. One of these lines is suitable for the more ordinary steam pressures and temperatures, while the other line has been especially designed for steam pressures up to 600 lb. gage and steam temperatures up to 750 deg. F. The design of the latter line includes many unusual features, such as stainless steel blading throughout, stainless steel governor valve and mountings, built-in heat insulation all over turbine—all in addition to the more usual features



CONDENSING ELLIOTT-KERR 2250-KW. UNIT



TANDEM-COMPOUND 45,000-KW. GENERAL ELECTRIC UNITS AT COLUMBIA HAVE STEAM REHEATED BETWEEN CYLINDERS



LOW PRESSURE UNIT OF 90,000-KW. GENERAL ELECTRIC UNIT UNDER CONSTRUCTION FOR CRAWFORD AVE.

of center-line support for entire turbine, all steel casing and water cooled bearings.

STATEMENT BY GENERAL ELECTRIC CO.

There was a remarkable increase during the year in the unit capacity of turbine-generator sets completed and under construction.

Units now in process of manufacture will extend the record with the installation of a 91,500-kw. unit in 1927, a 94,000-kw. unit in 1928, and a 208,000-kw. unit in 1929.

The fact that these last three units are being constructed for dates of installation so far in the future is an impressive illustration of the foresight necessary today in the central station industry.

The 208,000-kw. set will be installed in the State Line Station of the State Line Generating Co. near Hammond (Ind.). This three-unit set will operate under steam conditions of 600 lb. pressure and 750 deg. steam temperature at the throttle. The steam, while passing from the high-pressure to the two low-pressure cylinders, will be reheated to 500 deg., with steam at boiler pressure and temperature.

The three elements will operate at 1800 r.p.m. The high-pressure turbine will drive a 76,000-kw., 0.85-power-factor main generator and each double-flow low-pressure turbine will drive a 62,000-kw., 0.85-power-factor main generator and a 4000-kw. service generator. The main generators are to be wound for 18,000 v. and each main and service generator will have its own direct-connected exciter.

During the year two important stations were placed in successful commercial service. They are the Columbia Park Station of the Columbia Gas and Electric Co. and the Richmond Station of the Philadelphia Electric Co.

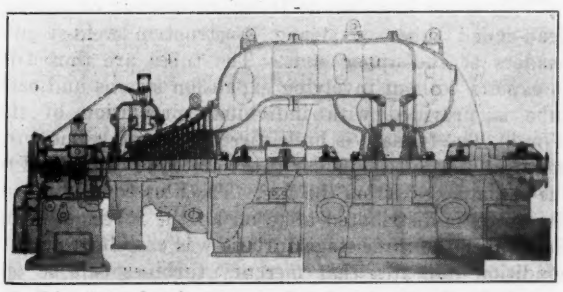
In the former, two 45,000-kw. tandem-compound units with single flow in the low-pressure end are installed. These machines operate with steam pressure of 550 to 600 lb. The steam is reheated between cylinders to its original temperature of 725 deg. F. Steam is extracted for feed-water heating.

The machines in the Richmond Station are of 50,000-kw. capacity and are also tandem-compound units but with double flow in the low-pressure cylinder. The steam conditions are 375 lb. at the throttle with a temperature of 675 deg. F. They also operate on the regenerative cycle.

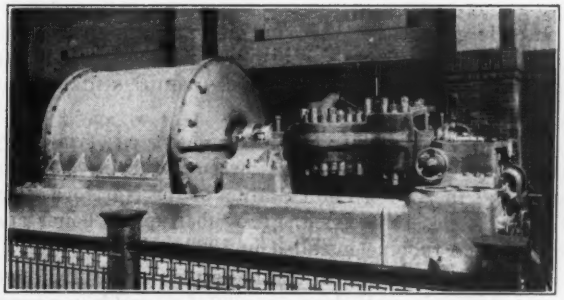
During the year there were in successful operation seven turbine-generator sets of 40,000 to 60,000 kw. in capacity under steam conditions of 550 to 600 lb., 700 to 725 deg. F. steam temperature with reheating after partial expansion.

The 77,000-kw. cross-compound turbine-generator set built for the Crawford Avenue Station of the Commonwealth Edison Co. of Chicago is now in successful operation and a 91,500-kw. unit of the same general design for this station is now under construction.

Other large sets completed include a 60,000-kw. single-cylinder, 25-cycle turbine generator for the Buffalo General Electric Co. and two 60,000-kw., single-cylinder, 25-cycle units for the East River Station of the New York Edison Co.



SECTION THROUGH 50,000-KW. TANDEM-COMPOUND GENERAL ELECTRIC UNITS AT RICHMOND



LAKESIDE HAS INSTALLED THIS 7000-KW. GENERAL ELECTRIC UNIT TAKING STEAM AT 1200 LB.

Two 52,500-kw. tandem-compound machines for the Societe Financiere de Transports for installation in Buenos Aires are designed for 550 lb. steam pressure and will operate on the reheating, regenerative cycle. This is the first development of this kind outside of the United States.

The fifth station in this country to use 550 to 660 lb. steam pressure is the Stanton Station, owned jointly by the American Gas and Electric Co. and the Electric Bond and Share Co. The initial installation consists of two single-casing units designed for operation on both the reheating and regenerative cycles. Each turbine drives a 40,000-kw. main generator and a 2000-kw. auxiliary generator.

A 52,800-kw. single-cylinder, 1500-r.p.m. unit built for the Southern California Edison Co. is now in service, and two 94,000-kw., 1500-r.p.m. tandem-compound units each consisting of a 90,000-kw., 100,000-kv.a., 15,500-v. main generator and a 4000-kw. auxiliary generator are in process of construction. Each turbine-generator will measure 103 ft. in length and weigh about 1,650,000 lb.

Unusual features of these machines include provision for future gas cooling of the generators and the combination of a double-flow, low-pressure end with four vertical condensers. They will be the first of their type to generate current at 16,500 v.

The first 50,000-kw., 1800-r.p.m., single-cylinder, single-flow turbine-generator set is practically completed and will be installed in the Cahokia Station of the Union Gas and Electric Co. of St. Louis, and two additional 50,000-kw., 1200-r.p.m. units for the Detroit Edison Co. are being built.

After a year's operating experience with the 1200-lb. turbine in the Edgar Station, the Boston Edison Co. states that "This high-pressure installation is not a full or complete development of the high-pressure possibilities in the Edgar Station and it is expected that a full development of this equipment will bring the generating records of the station down to a kilowatt-hour for 9/10 of a pound of coal." No difficulties attributable to the high pressure have been encountered. It is no more difficult to operate such a machine than one for standard pressure and it seems entirely feasible to develop much larger units.

A 7000-kw. machine, as shown, designed for the same initial conditions but for somewhat lower back pressure for The Milwaukee Electric Railway and Light Co. is also operating commercially.

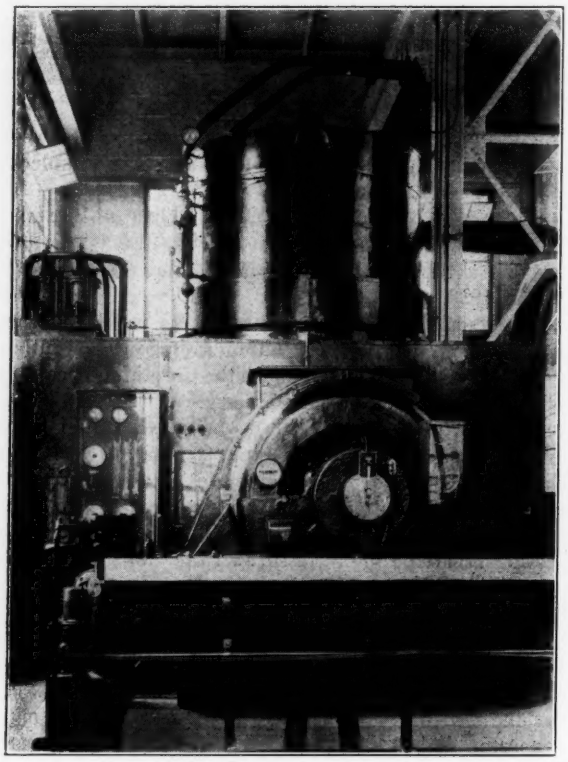
Stainless steel is now utilized for all buckets except those in contact with very high temperature steam and those long buckets in the last few stages in the exhaust end of large machines. Steam, mechanical and electrical research were diligently continued in order to build an ample foundation for the future requirements of the industry.

During the summer of 1925 a new type of mercury boiler and a new three-stage mercury turbine were installed at the Dutch Point Station of the Hartford Electric Light Co., replacing the fire-tube type of boiler and single-stage turbine installed in 1923.

Preliminary tests during the latter part of 1925 and early 1926 showed the necessity for making several minor changes and repairs to the mercury boiler. These were made and by the end of April, 1926, the boiler was again ready for operation. From then to the end of August the equipment carried commercial load during the day, being shut down at night and over week-ends.

During these periods of operation, certain tubes seemed to heat more than others and experiments proved that this irregularity arose from certain interference with the liquid circulation by the escape of vapor near the down circulation tubes. Improvements to prevent the possibility of such interference were applied to the Hartford boiler.

Since this change the apparatus has been operated at the highest loads which the generator is capable of carrying. The heating of all boiler tubes is apparently uniform and everything indicates a stability of action with a wide margin of capacity. The furnace was altered to burn pulverized coal, replacing the oil burners previously used.



MERCURY VAPOR EQUIPMENT AT HARTFORD, SHOWING TURBINE GENERATOR AND CONDENSER

This boiler installed at Hartford consists of vertical dead-ended tubes of strong construction welded into headers at the upper ends. The tubes are thus free to expand without involving expansion strains and each tube is provided with individual circulation of the liquid. The furnace is built directly below the mercury boiler so that all the boiler tubes are equally exposed to the radiant heat from the fire. The heat concentration, therefore, is distributed alike on all the tubes. During September the three-stage turbine was examined and its condition indicates that mercury turbines can be operated for long periods of time without any part requiring renewal.

It is expected that a large commercial mercury unit will be constructed for installation at the South Meadow Station of the Hartford Electric Light Co. It is estimated that it will consume 14,400 lb of coal per hour and will deliver 10,000 kw. from the mercury generating unit. In addition, the condensing mercury will generate 124,000 lb. of steam per hour which will be superheated up to 750 deg. F.

While the development of hydro-electric systems was overshadowed by the enormous expansion which occurred in the steam-driven equipment of the public utilities, the aggregate capacity of waterwheel generators produced was greater than in 1925. At the close of the year there had been completed, or were under construction, more than 30 units rated at 10,000 kv.a. and above.

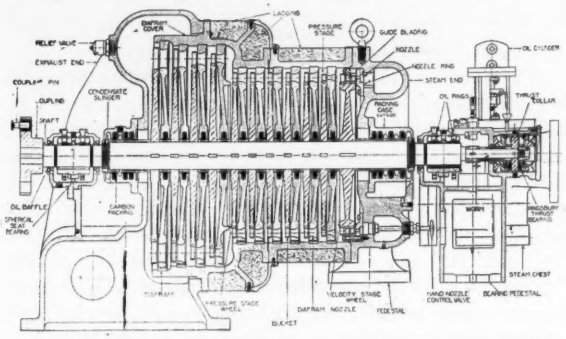
There was a notable increase in the use of the spring-type thrust bearing, especially for the larger units, and a more general adoption than heretofore of a closed system of air circulation whereby the heated air is passed through water-cooled radiators and recirculated. In many cases, steel-plate construction was utilized in both rotor and stator in order to minimize the use of the heavy castings.

Among the larger machines completed were three 37,500-kv.a., 12,000-v., 60-cycle, 120-r.p.m., vertical-shaft units for the Cherokee Bluff Station of the Alabama Power Co.; and two 33,000-kv.a., 11,000-v., 60-cycle, 360-r.p.m. units for the Sao Paulo Light and Power Co. of Brazil. These latter were horizontal-shaft machines.

There were also two horizontal-shaft machines rated 25,000 kv.a., 11,000 v., 450 r.p.m. for the Buck's Creek Power Station of the Feather River Power Co.; and two rated 13,000 kv.a., 12,000 v., 500 r.p.m. for the Tachiro No. 2 Station of the Tokio Denryoku of Japan.

Statement by Moore Steam Turbine Corp.

In our multi-stage turbines the principal development of the past year has been the reduction of water rates through the use of improved nozzles and the use of several steps in wheel diameter when necessary.



CROSS-SECTION OF MOORE MULTI-STAGE STEAM TURBINE

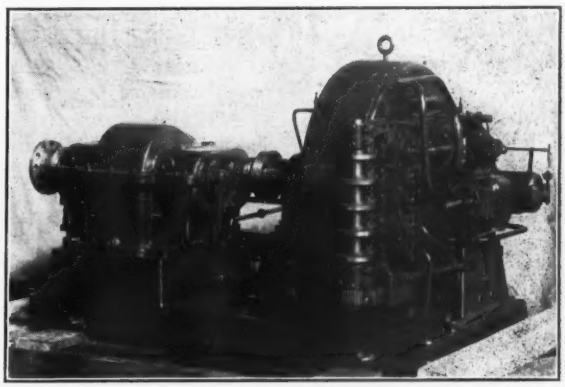
We find that the industries using steam in process and heating work are becoming much interested in the production of by-product power, from steam which must be reduced in pressure before being applied to process work. The higher steam pressures in common use today are making possible large returns from the use of turbines as power-producing reducing valves.

The increasing demand for bleeder turbines has justified us in making improvements in our bleeder turbines and in bringing out additional sizes of combined mixed pressure and bleeder turbines. We are also prepared to build turbines for bleeding at two pressures, both pressures being automatically controlled.

Statement by B. F. Sturtevant Co.

In the application of complete automatic nozzle control to auxiliary turbines an interesting recent development has been made. In the past, manual control of the nozzles has been considered sufficient in connection with a standard throttling governor. To increase efficiency at partial loads it has been found worth while to control nozzles automatically.

The Sturtevant turbine is fitted with a number of nozzles. In central station work it is difficult to make certain that the minimum number of nozzles is used for a given load. The result is the turbine is running



STURTEVANT TURBINE FOR AUXILIARY DRIVE FITTED WITH AUTOMATIC NOZZLE CONTROL

heavily throttled for a considerable percentage of the 24 hr. In this new development we have arranged the nozzle valves so that they are directly controlled by cams on a master camshaft. The shape of the cams and size of the nozzles may be so selected that practically any operating characteristic may be met with the highest efficiency.

The photograph shows a unit fitted with this type of control. In this particular case the master camshaft is rotated by means of a rack and a piston controlled by oil pressure.

Automatic nozzle control is not new in principle, but its application to small auxiliary turbines is unusual and is an important step in increasing their efficiency.

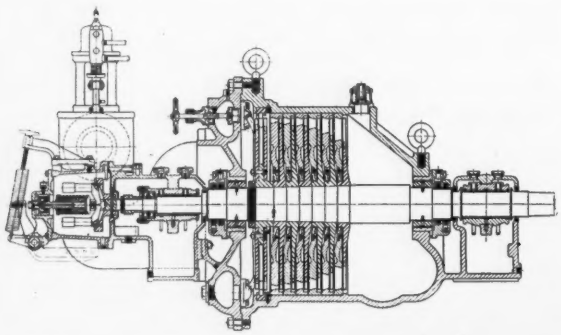
Statement by The Terry Steam Turbine Co.

The number of impulse stages we build varies according to the size of the turbine from 1 to 11. We have found 11 stages when employed with the proper wheel diameter to be the most economical for the size of machines we manufacture; that is, 1 to 1500 hp. These turbines are designed so that the number of stages may be varied according to the particular operating conditions of any individual plant.

For the low pressure stages we use the Rateau principle employing relatively low steam velocities. In order to secure high efficiencies we have full peripheral admission for the low pressure element.

Our bleeder turbines, as well as our mixed pressure turbines, are constructed so that the casing may be tapped either for bleeding or for admitting low pressure steam at the most efficient stage. For example, for high pressures, such as 75 or 100 lb., steam can be bled from the first stage. For the lower bleeder pressures, such as 5 or 10 lb., steam can be bled from the second or third stage. This enables us to obtain the highest efficiency of the bleeder element.

The type of governor depends upon the size of the turbine. For small units we use a governor mounted



SECTION THROUGH 7-STAGE COMPOSITE DESIGN TERRY TURBINE

directly on the turbine shaft and operating the governor valve without intervening mechanism. For larger units and also where close regulation is required, we use an oil operated governor valve actuated by a governor mounted directly on the shaft. For paper machine drives we have developed a variable speed governor which permits a speed range of 1 to 8.

On all our units an entirely independent over-speed valve and over-speed governor are available. We consider this absolutely necessary for the safe operation of any turbine, because most over-speeding is caused by a leaky governor valve. If this governor valve serves also as an over-speed valve, it may fail to shut the machine down.

Since we use the impulse principle throughout for our machines an equal pressure exists on both sides of each individual wheel. It is not necessary, therefore, to provide balancing pistons to take up the thrust. To take the slight end thrust caused by the impact of the steam on the wheels and to maintain the wheels in a definite position, a ball thrust bearing is used, mounted on the governor end of the turbine. For single stage machines using the Terry wheel, the thrust is practically nothing and the wheel is held in position by two collars integral with the shaft and located at each end of one of the bearings.

STATEMENT BY WESTINGHOUSE ELECTRIC & MFG. CO.

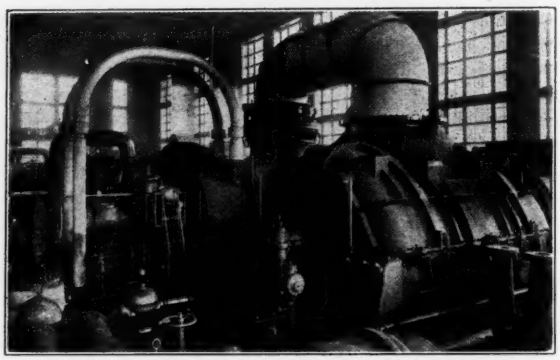
During the past year the company has put in operation at the Hudson Avenue Station of the Brooklyn Edison Co. an 80,000-kw., cross-compound unit, which is the largest generator unit in operation at this time. Work has been started on a 104,000-kw., cross-compound unit for the Commonwealth Edison Co. of Chicago. This is to operate with a steam pressure of 550 lb. gage, total temperature of 725 deg. Between the two main turbine elements steam will be reheated at about 45 lb. absolute pressure to 500 deg. by a live steam reheater. Both elements of the turbine will operate at 1800 r.p.m.

A single cylinder turbine of 31,000 kw. capacity is under construction to operate at 600 lb. pressure and 725 deg. total temperature. This is a step in the direction of reduced fixed charges.

For the Solvay Process Co. of Syracuse, N. Y., two important turbines have been designed to operate with certain industrial processes. These turbines will take steam at 800 lb. per sq. in. gage exhausting to the process at 165 lb. gage. Each turbine is designed for a flow of 150,000 lb. of steam an hour, with which it will develop 4740 kw.

Unique features of these two machines are the forged steel cylinders formed from two rectangular blooms and the means adopted for preventing strains from being induced in the turbine by the long high pressure exhaust pipe and of preserving the alinement of the apparatus on account of the high ratios of expansion.

Important improvements in the construction of details of steam turbines have been consummated. One of these is the design of a thrust bearing which is successfully operating with a maximum pressure of 530 lb. per sq. in. of effective area of the thrust bearing shoes. This allows a material reduction in diameter of dummies or balance pistons, thus reducing steam leakage.



WESTINGHOUSE 80,000-KW. TURBINE NOW IN OPERATION AT HUDSON AVE.

An entirely new form of regulating apparatus for steam turbines, responsive to oil pressure delivered by an impeller on the turbine shaft, was developed some years ago and for four years has been standard on our 3600-r.p.m. machines. The results obtained with this apparatus have been so satisfactory that it is now being employed on larger sized turbines, such as the 104,000-kw. unit for the Crawford Avenue and the Solvay Process Co.'s machines referred to above. This device has also made possible the development of certain small vertical shaft turbines, a number of which have been used in the oil refining industry.

A new skeleton frame construction replaces the former heavy design, this frame being strong enough to support itself during machining and assembly. Special provisions are made for handling during assembly and shipment and it has been so designed that the completely assembled unit can be shipped direct to its destination, ventilation requirements being cared for by an external structure of sheet metal applied at the destination. With this construction 1800-r.p.m. turbine generators up to

75,000-kv.a. capacity can be built and wound at the works and shipped complete.

In the construction of generators the company has developed half coils in which the strands of each conductor are arranged in groups and the strands of each group are transposed internally. Complete groups are then transposed at the ends of the machine. This results in coils relatively easy to handle and assemble and the eddy current loss factor of the winding can be made as low as possible.

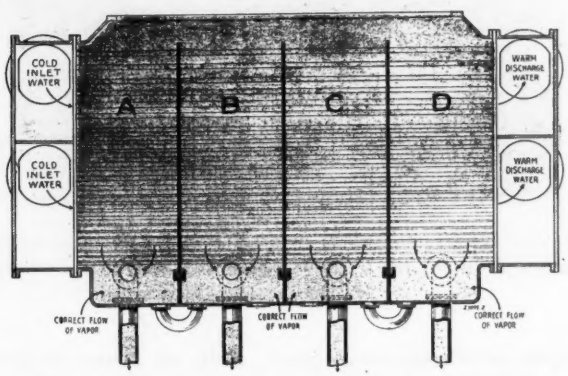
Large vertical water wheel generators have been built, such as the three 40,000-kv.a. machines at 82 r.p.m. for the Susquehanna Power Co. The overall diameter is 37 ft. and the total weight of the unit about 1,000,000 lb. The unit includes an auxiliary generator with its direct connected exciter. This auxiliary generator, rated at 700 kv.a., supplies power for motor-driven exciting sets, which supply excitation to the main generator. This machine also involves the greatest load on the thrust bearing and its supports of any unit ever built by the company, this load amounting to 750 tons.

For the Southern California Edison Co., two large horizontal water wheel type generators are being built rated at 50,000 and 45,000 kv.a. at 60 cycles and 50 cycles, respectively.

Progress in Condenser Design

STATEMENT BY INGERSOLL-RAND CO.

WIDESPREAD DISCUSSION has naturally resulted among engineers as to the relative merits of single and two-pass designs. It is axiomatic that the poorer the efficiency of the condenser, the greater the number of times the water must travel back and forth through the tubes to absorb the heat, and conversely, the more efficient the construction the fewer are



INGERSOLL-RAND CO. DIVIDE THEIR CONDENSER INTO FOUR COMPARTMENTS TO TAKE CARE OF UNEQUAL LONGITUDINAL STEAM DISTRIBUTION

the necessary passes of the water. Since the majority of installations call for two passes in the conventional design, the greater efficiency of Ingersoll-Rand design usually manifests itself in single-pass construction. In certain fields of application, however, it is desirable to use Ingersoll-Rand two-pass condensers, and such condensers take the place of older four-pass designs.

In order to eliminate waste tubes from a condenser it is necessary to have hot active steam flow over all the tube surface. Then too, only a small vacuum pump must be required. In the Ingersoll-Rand design this is accomplished by a combination of tube staging, shell shape and external air coolers. These features solve the problem only when considering a condenser of very short length.

Considering the steam distribution longitudinally, another set of conditions must be overcome. Condensers have different capacities along their longitudinal length, and even if perfect penetration and distribution are accomplished in a short length by the features of design already described, they will not be obtained automatically for the entire length of longer units.

In Ingersoll-Rand condensers this is now corrected by independent vapor and air removal from each of the four sections into which the condenser is divided. The cut shows a condenser in which each section is made in effect a separate condenser by steam tight baffles because each section has a separate vapor outlet and a different vacuum is maintained for each section. Section A, for example, is supplied with cold water and a much greater condensing capacity than D, so that a higher pressure drop is required. This is secured by having an independent vapor outlet.

It should be noted that the problem of longitudinal distribution exists in all condensers, regardless of the number of passes. With certain combinations of number of passes, load and water flow, a condenser may approach balance without the special provisions described above, but this is not a stable condition. In small condensers it is complicated by the impact of the steam entering a relatively small central exhaust nozzle. In the Ingersoll-Rand condenser, complete utilization of all surface is insured by making positive provision for supplying every square foot with an active steam flow.

STATEMENT BY HENRY PRATT CO.

During the year 1926 we have furnished 14 Phillips Expansion Joints for units of 10,000 kw. or over, four of which are for 50,000-kw. units. Among the latter are two for Stanton Station and one for Cahokia.

This expansion Joint, now in its fourth year of successful service is a flexible connection for use between the exhaust flange of a steam turbine and its condenser where extreme flexibility, lightness and simplicity are essential.

Recently a joint 12 ft. in diameter which had been in service for 3 yr. was operated continuously under atmospheric exhaust conditions for 21 hr., the maximum movement due to the unequal expansion of the exhaust stack, as measured by the customer's engineers, was $\frac{3}{8}$ in. horizontally and $\frac{3}{16}$ in. vertically. The non-condensing operation was due to the loss of circulating water and immediately after circulation was regained maximum vacuum was obtained. The rubber element, examined later, showed no ill effects from this service and is still in use.

Employing a 2½-in. O. D. by 1½-in. I. D. all-rubber tubing as the flexible medium, the Phillips expansion joint is water-sealed and has been so designed that the rubber element is thoroughly protected from all conditions that would tend to injure it. It may be removed and replaced on the largest size joints in less than 2 hr. time at small cost and should a leak occur, it may be stopped during the operation of the unit, by means of adjusting screws which hold the rubber element in place.

Since the employment of steam turbine generators of large capacity, the problem involved in setting and connecting condensers has been of serious importance. Exhaust connections between turbines and their condensers frequently exceed 200 sq. ft. in area and 12 ft. in length. In such installations the condenser and exhaust connection will weigh, in operating condition, from 300 to 400 t., of which perhaps 50 t. of circulating water is an unstable load. It is obviously preferable to mount such masses of apparatus on rigid foundations. A condenser grouted on concrete or steel foundations does not require flexible connections to its auxiliaries and atmospheric exhaust pipe, and the slight vibration of the turbine generator is not transmitted to the condenser tubes causing tube wear and, frequently, increased tube leakage.

STATEMENT BY THE WESTINGHOUSE ELEC. & MFG. CO.

General improvements have been consummated, particularly in the construction of hotwells, in which some degree of evaporation is produced. These have been found particularly successful in effecting deaeration. This construction should render the installation of deaerators unnecessary.

Novel construction of single-pass condensers have been developed in which the tubes are expanded into the tube plate at both ends, eliminating leakage incidental to tube packing. In this new construction, expansion is provided for by an annular diaphragm interposed between the tube plate and the outer shell of the condenser.

STATEMENT BY WHEELER COND. & ENG. CO.

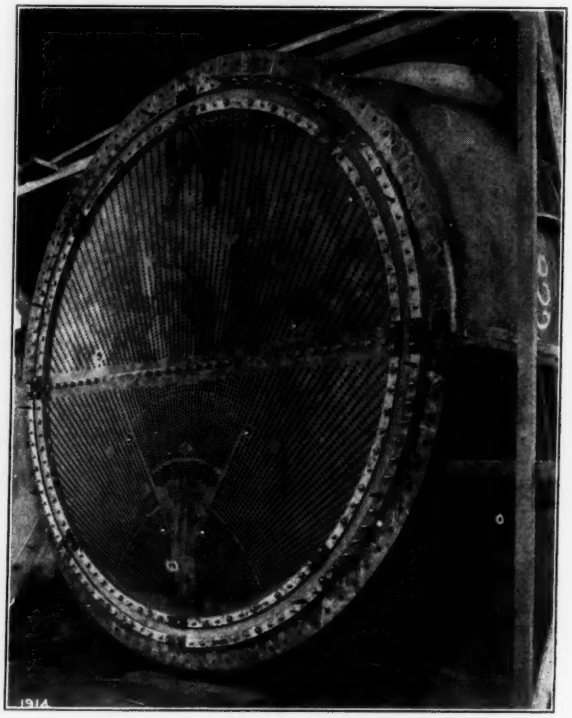
We have adopted the "Direct Flow" tube layout as a standard for single and two-pass condensers above 10,000 sq. ft. in area. A condenser with this tube layout is shown in the photograph, with the tubes arranged on straight lines converging from the turbine exhaust to the air pump suction so that the least resistance is offered to steam flow. It has been found that with this straight line arrangement of tubes, the pressure drop through the condenser, as shown by the cooling of the condensate below steam temperature is practically negligible.

A circular shell, somewhat larger than the tube bundle, is usually employed in Wheeler condensers. The resulting steam lanes on each side of the tube bank permit better distribution of steam to the tubes. The center portion of the tube bank directly under the turbine exhaust where velocity of steam is the highest, is the deepest, and the sides of the tube banks, where the steam has little initial velocity, are the shallowest. In single-pass condensers, the turbine exhaust is offset towards the circulating water inlet. The end of the tubes nearest the inlet are coldest, and have the greatest condensing capacity. By locating the turbine exhaust directly over this end of this condenser, the steam is projected at high velocity on these tubes and penetrates to the bottom of the tube bank.

Straight line arrangement of the tubes with low pressure drop through the tube bank makes it possible to secure the correct longitudinal distribution of the steam by the velocity of the steam alone, without using vapor tight partitions or other mechanical devices, while the Direct Flow layout with the flow of steam between each row of tubes has been found to give better steam distribution and to offer less resistance to the flow of steam than a solid tube bank cut by preferential steam lanes.

Use of one or two-pass condensers depends entirely on circulating water conditions. Equally efficient machines are constructed on both designs. Two-pass construction is used where the external head on the circulating pump is high, and single pass construction where the external head is low. Divided water boxes are used for installations where it is desired to clean one half of the condenser with the other half in service. Wherever possible, however, this arrangement is avoided, as it is not very satisfactory due to the air leakage through the tube packing in the open half of the condenser.

In the new Wheeler condenser with floating tube sheet the tubes are expanded in both tube sheets to eliminate tube packing, and one of the sheets is floated upon rubber expansion joint. Tests on a unit of this type have shown no leakage detectable with a conductivity meter. It is thought this construction will be exceedingly desirable for plants having salty or polluted circulating water, as a small amount of condenser leakage with such water may easily introduce more solids into the boiler feed system than the use of untreated makeup water. An expansion joint of the type used between the turbine and condenser is employed. The weight of the tube sheet and tubes is taken upon two brackets forming a cradle support. The above photograph of a unit for a large central station nearing completion, illustrates the construction of the floating head.



A NEW WHEELER COND. & ENG. CO. CONDENSER TUBE HEAD WITH AN EXPANSION JOINT ALLOWING BOTH ENDS OF THE TUBES TO BE EXPANDED

Proper steam distribution by tube arrangement and exhaust location gives practically uniform expansion in

all parts of the condenser and removes the difficulties of unequal expansion of earlier types using this type of joint. Temperature readings taken from tubes in different parts of the condenser show only a few degrees difference between the outlet temperature of the tubes at the extreme bottom and through the top.

Reversal of water flow through the condenser has proven to be a satisfactory method of cleaning the water surfaces of condensers, or rather keeping them clean. This not only removes debris from the tube sheets, but stirs up the mud deposited in the tubes and sweeps it out. A new design of single pass condenser which simplifies the piping needed for reversal of flow is shown in the drawing.

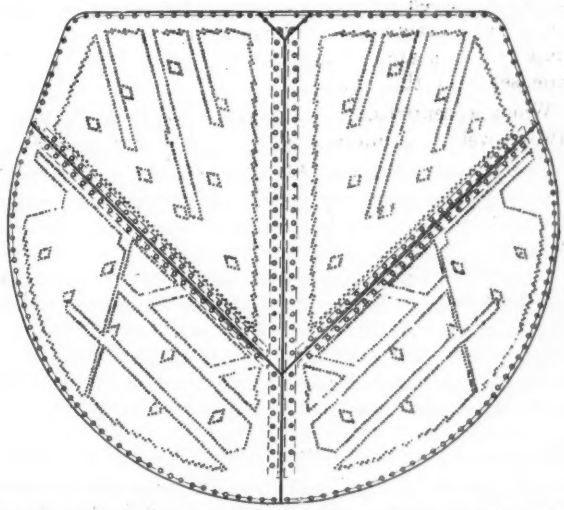
Two circulating pumps, one at each end, are used and the condenser fitted with a motor-operated flap valve as shown in the end elevation. Water from one pump flows through the other half of the condenser. By reversing the position of the motor-operated flap valve the direction of the water flow is reversed.

Hotwells should be provided with a baffle over the condensate outlet to prevent the entrainment of vapor by the hotwell pump. Storage hotwells, sufficiently large to compensate for temporary variations in water requirements are recommended. These hotwells store the surplus water under a vacuum out of contact with air, so that air is not introduced into the boiler with every variation in water level. The use of a storage hotwell also simplifies station piping.

Variable speed drive is employed on hotwell pumps wherever possible for the purpose of insuring that the hotwell pump runs full. Specifications usually require that the hotwell pump have a large overload capacity and if provision is not made for reducing the speed of the pump at part load, it will run part empty with vibration. Manual regulation is used with motor drive. With turbine drive a float in the hotwell may be employed.

Statement by The C. H. Wheeler Mfg. Co.

For service with modern high vacuum turbines of large capacity, we employ surface condensers of the dual bank design similar to the illustration, in which, as the name implies, there are two banks of tubes separated by a center steam lane. Tubes are so spaced that all the tube surface will be active and the air and non-condensable vapors removed with a negligible pneumatic pressure drop through the condenser.

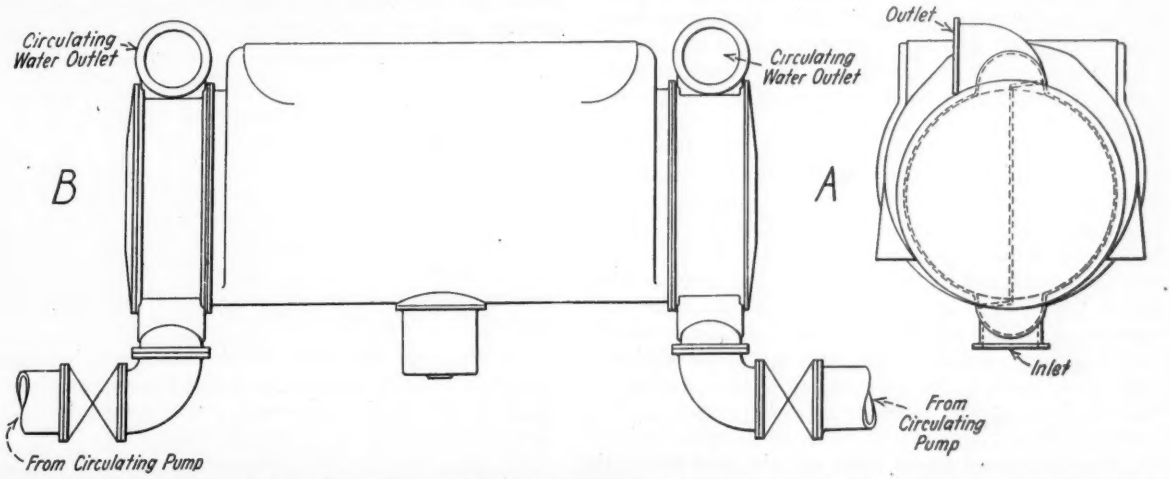


DUAL BANK TUBE SHEET ARRANGEMENT WITH STEAM LANES TO GIVE PROPER STEAM DISTRIBUTION AS USED BY THE C. H. WHEELER MFG. CO.

A cylindrical form of shell with the addition of a steam dome is used and steam flow passages consist of the center lane above mentioned with certain and various auxiliary lateral steam lanes to provide for minimum pneumatic pressure drop.

The large majority of surface condensers are of the two-pass design. Larger sizes can be provided at practically no extra cost with divided water boxes so that either half of the condenser may be operated while the other half is shut down to be cleaned. This allows continuous operation of the turbine, and with only a slight reduction in vacuum during the cleaning operation. The method of cleaning depends entirely upon the nature of the deposit in the tubes.

Present day methods for large condensers provide for deaerating the condensate and any other returns that may be added thereto, and the oxygen content



SPECIAL WHEELER COND. & ENG. CO. SINGLE-PASS CONDENSER CONSTRUCTED WITH A MOTOR-OPERATED FLAP VALVE FOR FLOW REVERSAL

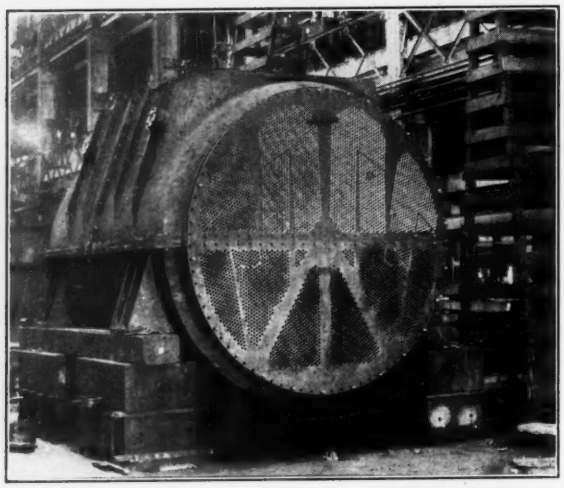
should not exceed 0.05 c.c. per litre. Steam ejector air pumps have practically eliminated all other type air pumps and the air is removed from both sides of the condenser near the ends.

When a centrifugal condensate pump is used the hotwell level is maintained by the pump characteristics, in other words, the pump impeller is so designed to regulate this. In the direct acting condensate pump, it is necessary to control this level by a float acting on the throttle.

Turbine bleeding gives less steam to be condensed and consequently less condenser surface is required for same size unit without such bleeding. Average water velocities of about 6 ft. per sec. are used with the temperature rise of circulating water allowable depending on the load and the quantity of water available.

STATEMENT BY THE WORTHINGTON PUMP & MACH. CORP.

As shown in the illustration the tube sheet layout of a surface condenser built by the Worthington Pump



TUBE SHEET LAYOUT DEVELOPED BY THE WORTHINGTON PUMP & MACH. CORP. TO PRESENT AN EXCEPTIONALLY LARGE COOLING SURFACE TO THE INCOMING STEAM

and Machinery Corporation has been designed for high efficiency and rapid heat transfer, with high temperature of the condensate and a low oxygen content of this condensate as it leaves the condenser. These results are attained by providing a short travel of steam flow through the tube bank, giving a minimum drop in pressure from exhaust inlet to air outlet, by reducing the number of tubes over which the air liberated by the condensed steam must successively pass, and by providing a belt of steam at exhaust inlet temperature through which the condensate must pass on its way to the hotwell. The tubes are arranged in the form of a flat narrow layer folded upon itself so as to form wide inlet areas and separate exit lanes which lead directly to the secondary and air cooling section of the condenser. The design is such that there is an exceptionally large amount of tube surface exposed to incoming steam, resulting in a correspondingly large initial reduction in steam volume.

Entering steam passes from an inlet lane across the tube layer to an exit lane, carrying with it the air liberated by condensation directly to the air cooler section, which is located in the lower central portion of the shell. The resistance to steam flow is practically only that due to the width of the tube layer, thus giving a very small pressure drop through the condenser and the liberated air flows directly to the air cooler section by way of the exit lanes without having to pass over the balance of the tube surface. This reduces to a minimum the insulating effect due to the presence of air on the steam side of the tube and prevents unnecessary reduction in the rate of heat transfer from this source.

Bottom sections of the tube bank and the exit lane connections to the cooler are separated from the steam belt by steel plates fitted with trapped slotted openings which are designed to spray the condensate into the steam belt for reheating and at the same time to prevent any short circuiting of steam from the steam belt to the air cooler section. The resulting condensate temperature is therefore very close to that of the steam entering the condenser and the oxygen content of the condensate reduced to a minimum.

Air cooler sections are separated from the main exit lanes by steel plates arranged in the form of an inverted "V" and are of gradually reducing cross sectional area up to the point where the air enters the longitudinal equalizing port from which the air suction openings lead to the vacuum pump.

The main features of this design are the short and equal path of travel for steam from inlet to exit lanes giving maximum vacuum at the turbine, reduction in the length of path of air passing over the tubes to favor heat transfer, and the provision for high relative temperature of condensate with a minimum oxygen content.

Electric Power Plants Great Savers of Coal

ELECTRICITY, WHICH has been used as a substitute for coal in so many ways, singularly enough has led to a substantial saving of that fuel. Since 1919, improvements in the generation of electricity have resulted in the saving of 75,000,000 t. of coal. Figures compiled by the United States Geological Survey show that during the last 6 yr. the consumption of coal and its equivalents in other fuels in central generating stations increased about 15 per cent, while the energy generated in those stations increased by almost 80 per cent.

This saving is attributed to a variety of causes—actual progress that has brought the consumption to a pound of coal per kilowatt-hour in the most up-to-date plants, the elimination of inefficient equipment, the growth of interconnections, and similar factors. And it is claimed that the saving is not alone in what the industry has not taken from the national coal pile during the past 6 yr., but in the price of coal, for competitive buying on the old scale would inevitably have marked up the general level of coal prices.

In one year the power plants that are to be classed as public utilities generate and distribute more electricity than do all the light and power companies of all the other countries in the world combined.

FOR STEAM lines with 80 deg. or more superheat, cast steel valves are preferable to cast iron.

ELECTRICAL DEVELOPMENTS

Air Cooling for Generators

STATEMENT BY AMERICAN BLOWER CO.

DESIGNERS of modern electrical machinery are now fully recognizing the importance of effective ventilation, particularly in the case of high speed turbo-generators which are small in proportion to their output and have consequently a limited space wherein only comparatively small channels can be embodied for the dissipation of the heat.

The use of external fans is now becoming more general, principally for the reason that they can be designed to give the maximum efficiency for a given duty and also because they offer the further advantage that they can be operated separately from the generator at any speed suitable to meet any change in atmosphere temperature.

As known from every day experience, the atmosphere contains suspended solid matter which cannot be regarded a normal part of its composition. Among the most important constituents of this atmospheric pollution are tar, carbonaceous matter, mineral matter, volatile matter, sulphates, etc.

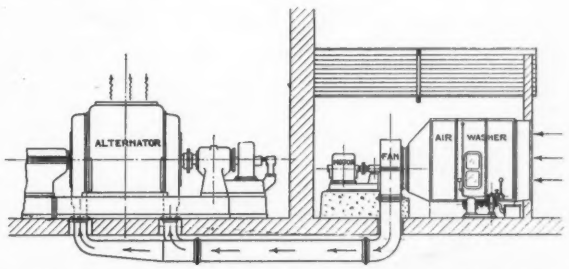
Since air has been so largely used for generator cooling, many failures of insulation have resulted and careful investigation has proved that this has been largely due to the presence of dirt and dust particles in the air, which have been gradually deposited on the windings, causing local overheating, since the dust prevents the transmission of heat from the conductors to the air. This local overheating gradually destroys the nature of the insulation, until it becomes too weak to withstand the voltage and therefore local "punctures" or "shorts" occur, or even a complete "burnout" of the windings may occur.

A supply of clean air, therefore, is an absolute essential in a successful plant and this has led up to the use of spray coolers, a typical installation being shown herewith.

The principal function of this equipment is to keep dust and dirt out of the electrical apparatus. The air washer has a second function in that it not only delivers clean air to the electrical apparatus but through absorption from the spray, the air temperature is reduced to so marked an extent as to provide an even greater cooling effect than is possible with the unwashed air. The eliminators placed immediately following the spray nozzles remove all traces of entrained moisture from the air current and as the air never reaches the saturation point, there is no opportunity for trouble from moisture in the insulation.

Development of closed air cooling systems for generators opened up the possibilities of using other gases than air as the cooling medium, such as carbon dioxide, nitrogen or hydrogen. The last named in the present stage of development seems to have advantages that make it superior to others, if the explosion danger can be eliminated. Experiments have shown that probably the explosive hazard has been over-estimated, although further investigations along this line may be desirable. A mixture of air and hydrogen containing more than 65 per cent hydrogen can not be ignited and this information would indicate that an infiltration of 35 per cent could be permitted before the danger zone is reached. Since the pressure in the system could be maintained slightly above atmospheric, the amount of infiltration may be reduced to a minimum.

Hydrogen is a nonsupporter of combustion, therefore, its use as a cooling medium eliminates the fire hazard. It has better thermal qualities than air and on this account a generator can be made to carry a greater load with hydrogen as a cooling medium.



TYPICAL AMERICAN BLOWER COMPANY INSTALLATION SHOWING METHOD OF SUPPLYING CLEAN AIR TO GENERATORS FOR COOLING PURPOSES

Further, with the use of standard air, it has been found necessary through general practice to provide a blower capable of delivering air against approximately one-third of a pound pressure, which pressure is necessary to circulate a cooling medium having density equal to that of air. Hydrogen having a density many times less than that of air, the power required to circulate it through the generator windings would be less than air by an amount approximately in proportion to the ratio of their densities and a marked economy might be realized.

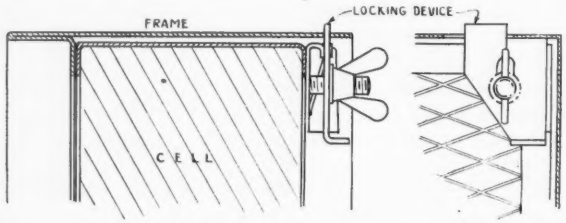
STATEMENT BY MIDWEST AIR FILTERS, INC.

Easy replacement of cells has been one of the problems attacked by our engineering department during the last year. We then developed the locking device shown herewith, which when tightened up firmly holds the cell in place and presses towards the rear edge of the frame, thereby forming an absolutely air-tight joint which eliminates any danger of dust passing between the cell frame and the cell. Only metal-to-metal construction is used for obtaining this tightening. No felt that softens when coming in contact with oil is used to form proper tightening.

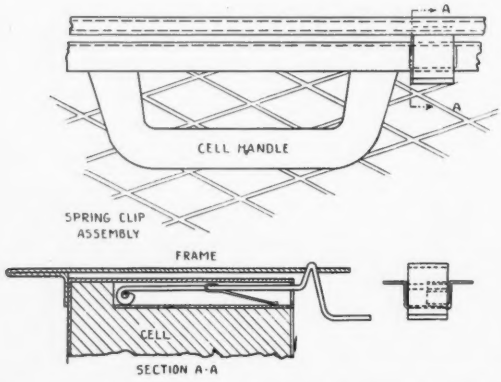
The next step in the development of tightening arrangement was the spring clip also shown here. This

clip is removed with the thumb when lifting out the cell and snaps back in place as soon as the cell is inserted in the frame. Practically good enough tightening is obtained with this spring clip only but in order to satisfy demands in various parts of the country, we furnish the locking device at all four corners and one spring clip on each of the two opposite vertical sides.

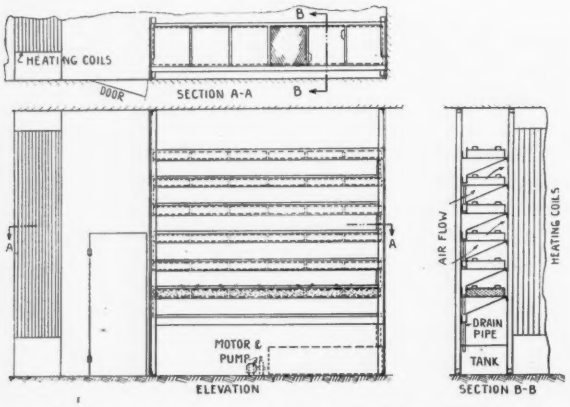
There is another improvement which is just being developed in detail at this time. This is the arrangement of filter cells in horizontal position. Previously filter cells had to be taken out every four to six weeks for cleaning but with the air first hitting the diagonal partition between the horizontally-placed cells the heavy dust is caught as that surface is oiled the same as the cells, leaving only the finer dust to be accumulated by the cell.



SECTION OF MIDWEST AIR FILTER UNIT SHOWING NEW STYLE LOCKING DEVICE

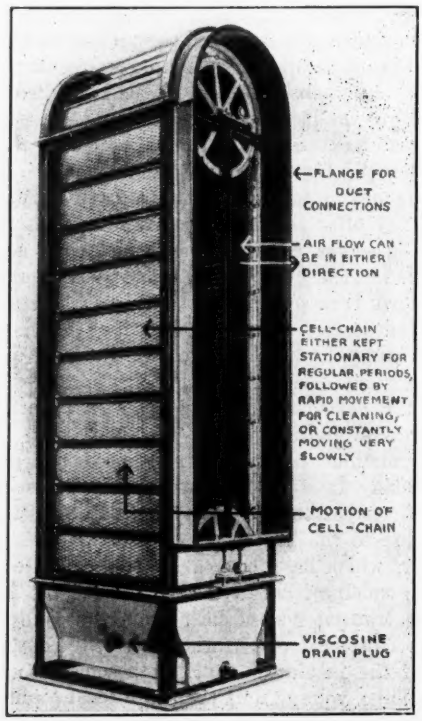


SPRING CLIP LOCKING DEVICE FOR MIDWEST AIR FILTERS



MIDWEST HORIZONTAL TYPE AIR FILTER INSTALLATION SHOWING MOTOR, PUMP, VISCOSINE TANK AND COMPLETE SET OF HORIZONTALLY-PLACED FILTER CELLS

One of the disadvantages of unit filters is the frequent removal of the cell for cleaning. With a horizontal installation such as shown on the above drawing, it is not at all necessary to remove any cells. The importance of this improvement is called to your attention by the fact that the old way of cleaning cost $750 a year besides daily supervision at the Public Library, New York City, while it now can be done for $50 per year with only monthly supervision. This development is one step towards making air-cleaning equipment self-cleaning and automatic. Another result of this effort is our self-cleaning filter, which is a comparatively new idea.


FLANGE FOR DUCT CONNECTIONS
AIR FLOW CAN BE IN EITHER DIRECTION
CELL-CHAIN EITHER KEPT STATIONARY FOR REGULAR PERIODS, FOLLOWED BY RAPID MOVEMENT FOR CLEANING, OR CONSTANTLY MOVING VERY SLOWLY
MOTION OF CELL-CHAIN
VISCOSINE DRAIN PLUG

MIDWEST SELF-CLEANING AIR FILTER WITH PARTS REMOVED TO SHOW DIRECT CONNECTIONS

While the horizontal set-up has so far been favored more by building engineers and architects, the self-cleaning filter is preferred by industrial engineers.

Statement by Schutte & Koerting Co.

Schutte & Koerting Co. is using Radiafin tubes on generator air coolers. These fins, which project radially outward from the pipe add greatly to the radiating surface. They can be supplied in both round and oval shapes. The average temperature range through which the air is cooled is from 148 deg. to 140 deg. F. The number of tubes and amount of tube surface is selected to meet the foregoing requirements with the cooling water available in each case.

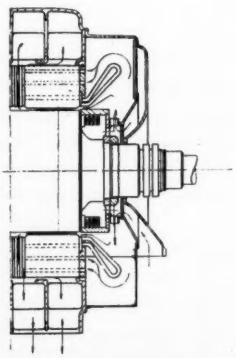
Both open and closed systems are employed and the coolers are made with sections arranged either horizontally or vertically or both. Each section has its separate tube sheet to allow for expansion, thus eliminating any possibility of stresses caused by temperature difference, moreover, by merely changing the connec-

tions, any one section can be used for raw water or for condensate. The counter flow principle is employed.

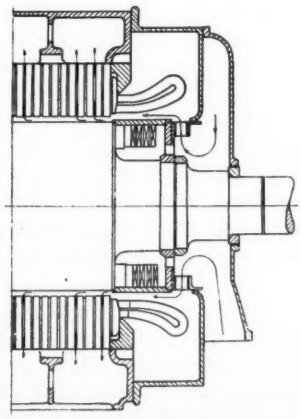
In the oval type, the slight vacuum or dead space, which is normally produced in back of the round tube, is eliminated to such an extent as to more than double the effective surface over that of a round tube of equal cross-section. This also diminishes the air pressure drop through the cooler. Another important advantage of the oval tube over that of the round tube is the small space requirements of the former.

STATEMENT BY WESTINGHOUSE ELECTRIC & MANUFACTURING CO.

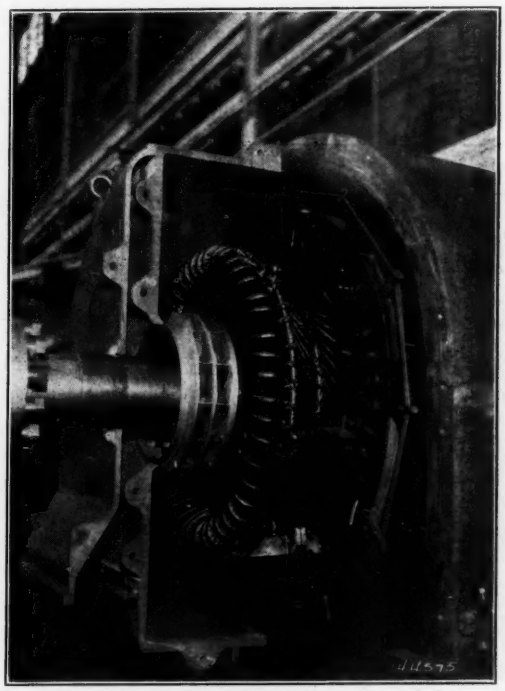
There has been no change in practice of the air temperature range through a generator. The inlet air temperature is held to a temperature not exceeding 40 deg. C. and in general the air rises 25 deg. C., passing through the generator giving an outlet temperature of 65 deg. C. The cubic feet of cooling air per kilowatt-hour loss averages 72.



AXIAL VENTILATION AS EMPLOYED BY THE WESTINGHOUSE COMPANY



SIMPLE RADIAL VENTILATION AS USED ON WESTINGHOUSE GENERATORS



ILLUSTRATING A WESTINGHOUSE GENERATOR WITH ITS END BELL REMOVED, SHOWING THE FAN AND SPACES FOR VENTILATION

Methods employed are illustrated in the accompanying figures. Most of our large machines that require additional cooling are using Griscom-Russell surface-type air coolers.

Many machines are equipped with sprinkler pipes inside the end bells. In case of fire inside the generator, water can be sprayed into the machine which will limit the extent of the fire. Connection between the sprinkler system and the house service mains is made outside the generator with a quick connecting fire hose to guard against unnecessary spraying of the machine or leaky valves.

Many machines are being made as air-tight as possible so that CO_2 can be used as a fire extinguisher. The equipment for the use of CO_2 is supplied by the Walter Kidde Co., and the only change required in the generator is to make it as nearly air tight as possible.

Transformer Development

STATEMENT BY ALLIS-CHALMERS MANUFACTURING CO.

AMONG transformers of notable interest, built during the past year by the Allis-Chalmers Co., four 15,000-kv.a., three-winding transformers having a high voltage of 132,000, medium voltage of 66,000, and low voltage of 12,000, formed a 45,000-kv.a. bank and spare. These transformers were provided with tap changes on the 132,000-v. winding so as to give a voltage range of four 2½-per cent taps above and below normal. The tap changes are suitable for operation when the transformer is fully loaded. The tap changer is motor-operated and is so arranged that taps may be changed and tap positions indicated from remote stations.

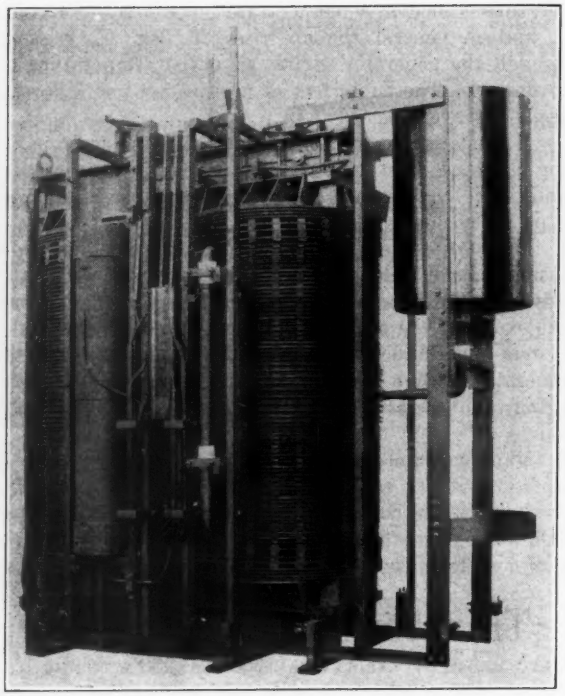
So-called industrial housings or "pot head construction" has been used by us on many of the transformers built during the past two years. Such transformers are so arranged that lead-covered cable can be brought directly into the transformer through the pot head, leaving no exposed live parts.

Several 10,000-kv.a. transformers are now being built to carry two-thirds load as a self-cooled transformer and then by means of an auxiliary motor-driven blower, which forces air on the radiators, the transformer may be made to successfully carry 100 per cent overload. On smaller power transformers we have adopted as standard the tubular-type tanks which consist of 2-in. tubes rolled into the tank and welded.

Due to some trouble in the east where paint has peeled off, we have installed a sand blasting outfit so that just previous to the time the transformer is painted, the whole tank is sand blasted which gives a perfectly clean surface for the paint.

STATEMENT BY GENERAL ELECTRIC CO.

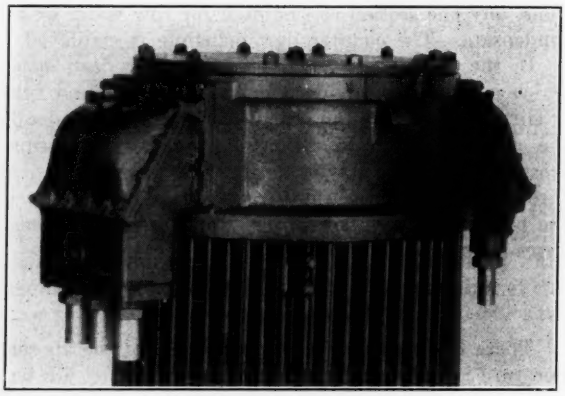
The largest artificially-cooled transformer unit built by the General Electric Co. was a 66,667-kv.a., 25-cycle auto-transformer for the Buffalo General Electric Company. This transformer is utilized to step up the voltage of a turbine generator line from 12,000 to 24,500 v. and its equivalent rating as a transformer is 34,000 kv.a.



GENERAL ELECTRIC TRANSFORMER SHOWING SIZE AND ARRANGEMENT OF CONSERVATOR

Due to its very large size, a five-legged core construction was used, to minimize the height and careful analysis of the flux distribution and losses demonstrated that they were well below the calculated values. The transformer is provided with two distinct windings, each of the high-voltage windings being connected through a separate circuit breaker to reduce the rupturing duty on the breaker.

An unusual condition had to be considered in the design and construction of 30,000-kv.a. and 16,700-kv.a.

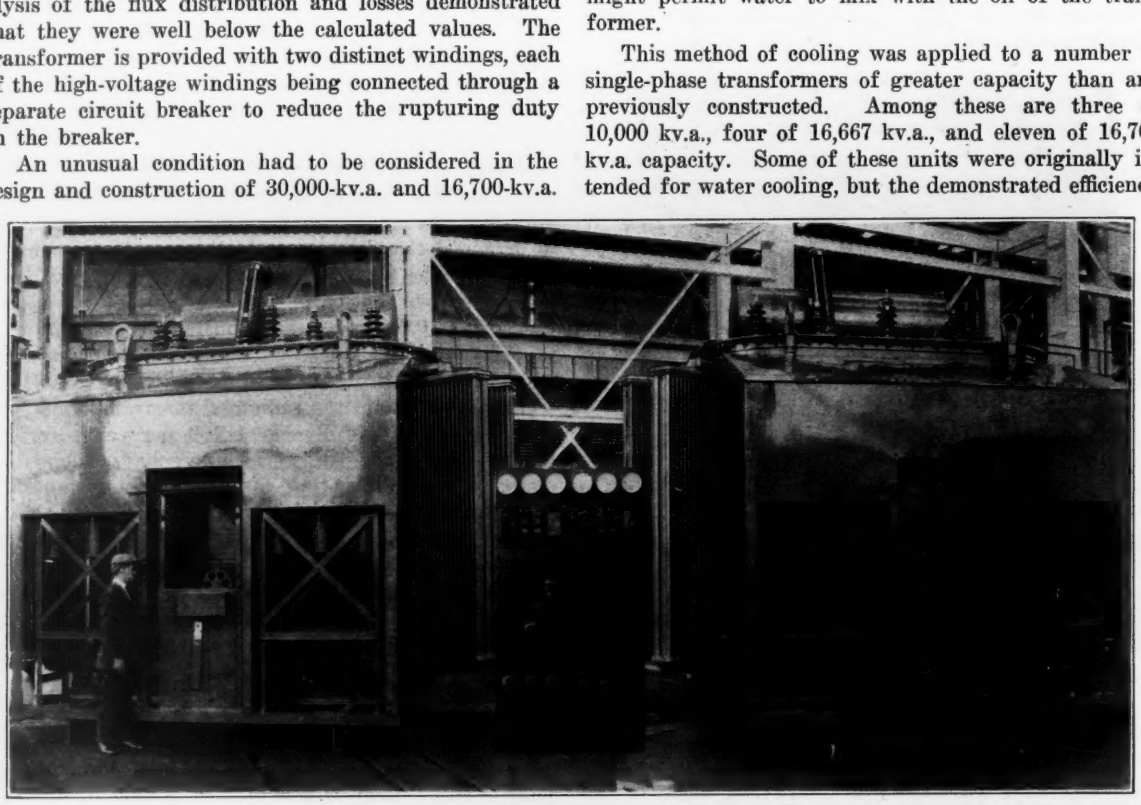


SUBWAY-TYPE TRANSFORMER BUILT BY GENERAL ELECTRIC CO., SHOWING ARRANGEMENT OF THE DETACHABLE JUNCTION BOXES

transformers for the Southern California Edison Co., in that it was necessary to provide these transformers with tanks capable of withstanding a 28-in. vacuum, so that they could be dried out under vacuum. The 16,700-kv.a. units are arranged for air-pressure cooling, and the radiators must also withstand the vacuum condition.

There was a notable increase in the use of oil-insulated transformers cooled by air jets applied to the radiating surface. This method of cooling is as effective as water-cooling and provides immunity from the possibility of frozen, leaky, or defective coils which might permit water to mix with the oil of the transformer.

This method of cooling was applied to a number of single-phase transformers of greater capacity than any previously constructed. Among these are three of 10,000 kv.a., four of 16,667 kv.a., and eleven of 16,700 kv.a. capacity. Some of these units were originally intended for water cooling, but the demonstrated efficiency



THREE-PHASE GENERAL ELECTRIC TRANSFORMER SHOWINGCONTROL PANELS IN CENTER FOR AUTOMATIC LOAD RATIO ADJUSTMENT

of the oil air-pressure method resulted in their being redesigned.

Four single-phase auto-transformers of record size were also arranged for air cooling. They are equipped with a conservator which contains 1300 gal. of oil and is in itself equivalent in dimensions to the tank required for a 2500-kv.a., 60,000-v. transformer. The weight of the conservator is approximately 5 t. and the total weight of the unit exceeds 130 t.

A subway tank was developed which is suitable for the larger capacities, higher voltages, and heavier currents, which are now being used, particularly in alternating-current networks. In this design the junction boxes which form an integral part of the tank provide adequate high-and-low-voltage terminal facilities; the high-voltage cables with their limited bending radii and the heavy low-voltage cables both enter vertically.

Use of these junction boxes permits the lowering of a larger tank through a given size manhole, since the box can be removed without breaking the main seals of the tank. The transformer may, therefore, be sealed and tested in the warehouse and the connections made or broken at the manhole without disturbing the seals. The junction boxes on one side are designed for 13,800 v. and on the other side for 120 v., in capacities up to 200 kv.a.

Because of their high dielectric and mechanical strength, Herkolite cylinders have been used for years in the major insulating and supporting structure of circular-coil transformers. The adoption of flanged collars of this material resulted in a marked simplification of the insulating and supporting structure at the ends of high-voltage coil stacks.

Built-up insulating supports used in combination with Herkolite flanges on the inside of the stack ends of transformers provided increased mechanical and dielectric strength at the points where the transmission line is brought into the transformer winding.

A detail improvement in the construction of small power transformers of 100 to 500 kv.a. capacity resulted in a reduction in weight of approximately 25 per cent, as well as a reduction in the head room required for installation. This consisted of the adoption of flat steel radiator piping which presents, for a given diameter of tank, a larger exposed radiating surface to the air, than was possible with the tubular radiators formerly used. Electric welding was used both for the formation of the radiators and their assembly.

Automatic control by means of a contact-making voltmeter was provided for two 3-phase, self-cooled, radiator type transformers of 10,000-kv.a., 60-cycle output each for the Cleveland Electric Illuminating Co.

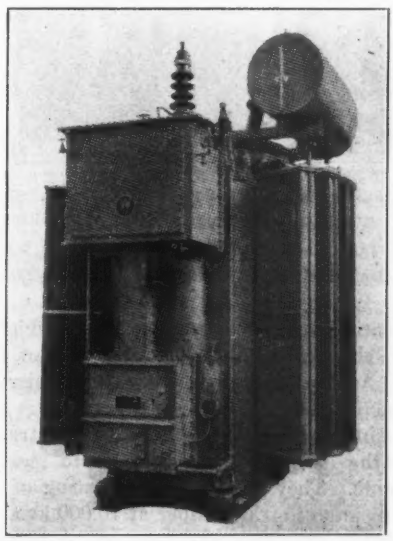
These machines transform 11,000 v. to feed a grounded Y, 41,400-v. system. To adjust the line voltage in accordance with the changing load, the high voltage windings have eleven taps of 2½ per cent each. To permit a change of taps without interrupting the load, a part of the 41,400-v. winding is made in two sections, operating normally in parallel and dividing the load equally. Each of these winding halves is connected to an 11-point ratio adjuster, and the resulting circuits brought out of the transformer tank and led to two 3-phase circuit breakers.

Contact-making voltmeters relieve the operator of any manual starting of the mechanism. If the line voltage deviates from a set value for a period longer than a predetermined time value, the tap-changing mechanism is automatically put in motion in one direction or the other to bring the voltage back to normal. A positive but adjustable time delay is insured by a relay, driven by a small induction motor. Between the motor shaft and the contact-making element a train of gears with a gear shift mechanism is introduced, allowing adjustment from 1 sec. to 30 min.

Two contact-making voltmeters are used on each of the two transformers, one adjusted to respond to a narrow range of voltage variations, while the other one is set for much wider differences in voltage. If the line voltage rises or drops only slightly, and if this condition persists long enough to bridge the introduced time delay, the transformer will shift to the next proper tap. If, on the other hand, a considerable rise or drop occurs, the second contact-making voltmeter will respond, and will cause immediate adjustment without any time delay. The necessary instruments, relays, timing devices, etc., are arranged on two switch panels.

Statement by Westinghouse Electric and Manufacturing Co.

The past year has seen many transformers arranged to change taps under load. Examples include two transformer banks, total capacity 63,000 kv.a. A preventive



SINGLE-PHASE WESTINGHOUSE TRANSFORMER WITH TAP-CHANGING EQUIPMENT

auto transformer is stepped along taps on the main transformer winding to change the voltage ratio of the transformers under load. By this method the mechanism is mounted outside the main transformer, avoiding the hazard of moving switches inside the transformer tank. A minimum number of taps from the main transformer is required.

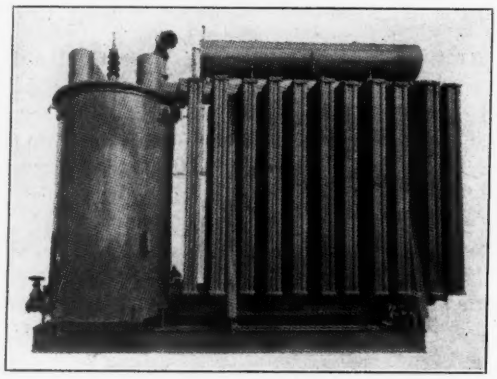
Each transformer has mechanism for tap-changing by remote motor control or manually. In the case of a 3-phase bank, a single-control switch simultaneously operates all three tap-changing mechanisms. Mechanical and remote-electrically-operated position indicators indi-

cate the tap position of each transformer. A differential protective system on each unit gives alarm signals if tap change is not completed.

Similar equipment was applied to four 20,000-kva., three-winding transformers, providing for tap-changing under load in both high and medium voltage windings. In a 3-phase bank, the transformer units have a ratio of 132,000 to 66,000 to 12,000 v. The units are single-phase combined, self-cooled and water-cooled with a rating of 25,000 kv.a. forced oil-cooled.

The first tap changer under load equipment with complete automatic control was installed on two 36,000-kv.a. transformer banks having a nominal voltage ratio of 132,000 to 11,500 v.

A new modification of the "preventive auto" scheme has greatly simplified the problem of tap-changing under load. An especially developed type of breaker for tap-changing service, is mounted in oil in the upper compartment, to switch the preventive auto transformer along taps on the main transformers.



UNUSUAL ARRANGEMENT OF RADIATORS BY WESTINGHOUSE TO MEET SPACE LIMITATIONS. THIS 89,000-KV.A. BANK INCLUDES THE LARGEST TRANSFORMERS ON WHICH SEPARATE RADIATORS HAVE BEEN MOUNTED

Automatic control is by voltage relays which respond to voltage changes in the low voltage side of the transformers. As the load varies, the mechanism changes taps to compensate.

Four single-phase, three-winding auto-transformers illustrate the design of transformers to meet unusual requirements. They have a voltage rating of 76,200 to 50,800 v. as an auto-transformer at 10,000 kv.a. A third winding rates 5000 kv.a. at 13,200 v. A bank of these transformers will deliver simultaneous loads of 30,000 kv.a. as auto transformers and 1500 kv.a. from the third windings. They will deliver 60 per cent of their rated capacity when self-cooled and full capacity with a blast of air against the radiators. The air blast is automatically regulated without attendance by an operator. As the load increases and decreases, the blowers automatically start and stop, preventing overheating and unnecessary operation.

Another special feature is a new design of tap changer in the high voltage winding. This operates when the medium and low voltage windings are loaded, with the high voltage winding excited but disconnected from the line. The tap change may be done by remote motor control or manually. The mechanism is interlocked with the high voltage winding and line to prevent operation of the tap changer before the winding is disconnected from the line.

Space limitations on an 89,000-kv.a. bank of self-cooled auto transformers, resulted in an unusual arrangement of radiators. The single-phase units of this bank are the largest transformers on which separate radiators have been mounted.

Transformer manufacturers have been interested in the possibility of obtaining a large overload rating on self-cooled transformers by air blast on the radiating surfaces. Westinghouse put out the first of this type nearly five years ago. These units were given a self-cooled rating of 5000 kv.a. and an overload rating of 6250 kv.a. with air blast on the radiators (both ratings based on a 55 deg. C. average rise in the windings).

Inertaire equipment has made rapid strides during the year as operating companies have become familiar with the way this equipment removes all oxygen and moisture from the gases in contact with the insulating oil, thus preventing oil deterioration from sludging and moisture.

An interesting new safety device is a small short-circuiting and grounding switch for distribution transformers, to be mounted inside the case, but to be operated from the outside. It short-circuits, and, at the same time, grounds, the high voltage winding.

A lock-out coil energized from the low-voltage winding of the transformer holds the switch in the open position by a cam as long as the transformer core is excited.

The external operating device can be padlocked in either the open or grounded position and tampering is further hindered by using a special socket wrench for the operation of the switch.

This switch is available for either single or 3-phase transformers.

Plant Switching Equipment

STATEMENT BY GENERAL ELECTRIC CO.

OF FOUR new types of oil circuit breakers recently developed, two were designed for outdoor and two for indoor service. The first, an oval tank type, for operation on circuits of 15,000 to 88,000 v., is one of the first oval tank breakers to employ an "internal" breaker mechanism totally enclosed in the top cover or breaker frame. This construction not only makes the mechanism absolutely weatherproof, but it also positively prevents the establishment of any unbalanced pressure on the contact operating rod, and thereby prevents the reclosing of the contacts after interruption of abnormal currents. Units of this type in capacities ranging from 175,000 to 500,000 kv.a. effectively bridge the gap formerly existing between those of the earlier oval tank and the present higher capacity round tank breakers. The design includes either finger-and-wedge contacts, or rod-and-segment contacts in explosion chambers, the latter type having the greater interrupting capacities.

One new type of oil circuit breaker has internal breaker mechanisms, separating chambers, triple-welded steel tanks, interchangeable bushings—in short, it possesses all the advantageous features of the higher inter-

rupting capacity breakers with the single exception of their contacts which, being of the wedge-and-finger type, make possible a considerable reduction in cost where a maximum of interrupting capacity is not required. These breakers are built for voltages of 110,000 v. and above, with normal current ratings of 800 amp. and with interrupting capacities of 500,000 to 750,000 kv.a.

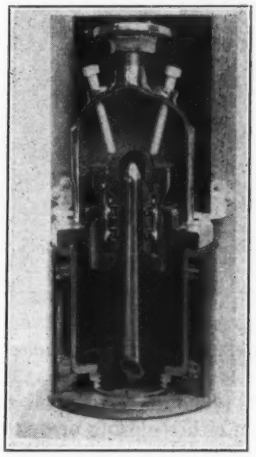
One of the new indoor breakers uses a separate round tank for each phase and is rated for 15,000, 25,000 or 37,000 v. with normal current ratings up to 3000 amp. and interrupting capacities from 400,000 to 1,500,000 kv.a. This type has an improved method of supporting the tanks, a more substantial mechanism and top frame, and improved contact construction in those units which are equipped with explosion chambers.

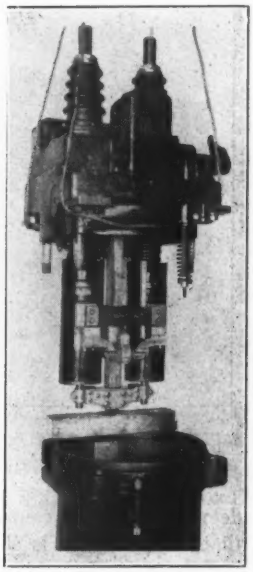
Increased use of truck-mounted oil circuit breakers resulted in the design of a new type of truck mounting. The truck and housing are entirely of steel construction, the operating mechanism is mounted on top of the truck, and the entire unit then rolls into the housing. An automatic shutter positively prevents contact with the live disconnecting devices when the truck is removed.

New motor mechanism providing "trip-free" operation has been especially designed for isolated-phase arrangements of large indoor oil circuit breakers. It has two sets of springs which, when charged by the operation of the motor, are released by operating the closing and opening control switches to effect, respectively, closing or opening of the breaker contacts.

To afford protection for underground network systems, an air circuit breaker of the double pole, magnetic blowout type was produced. The breaker and equipment are mounted in a water and gas-tight box, suitable provision being made for incoming and outgoing leads, and are arranged so that the breaker can be opened or closed by hand from the exterior of the box when such operation is necessary. The open or closed position is indicated by lamps, visible through colored lenses from the outside of the enclosing case. An improvement in the operating mechanism of self-contained solenoid operated circuit breakers provides a thoroughly dependable latching arrangement combined with a closing toggle mechanism which insures the secure latching of the circuit breaker in the closed position and requires but a small amount of power to unlatch it, making a greater range of calibration possible without the necessity of delicate adjustment.

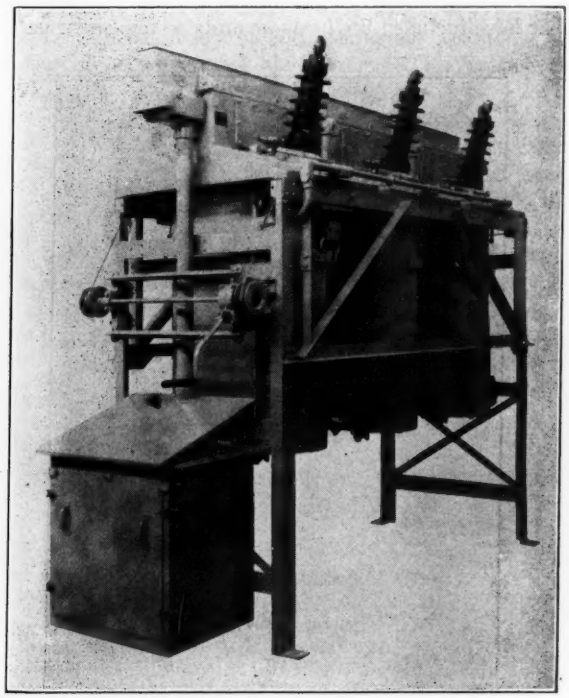
In order to protect polyphase lines against undervoltage, open phase, or reverse phase rotation, there was produced a relay consisting of a watthour meter magnetic element with two potential coils. These coils are so connected that under normal conditions they hold the relay contacts closed. If the voltage drops below a predetermined value the torque developed by the relay



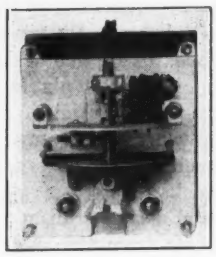


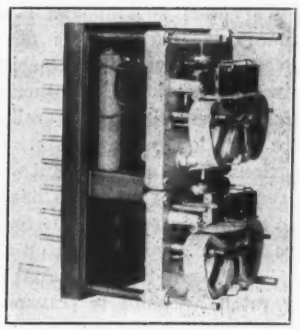
SECTIONAL VIEW OF EXPLOSION CHAMBER OF GENERAL ELECTRIC OIL CIRCUIT BREAKER SHOWING ARRANGEMENT OF ROD AND SEGMENT CONTACTS

UNIT POLE OF GENERAL ELECTRIC OIL CIRCUIT BREAKER SHOWING ARRANGEMENT OF WEDGE AND FINGER CONTACTS



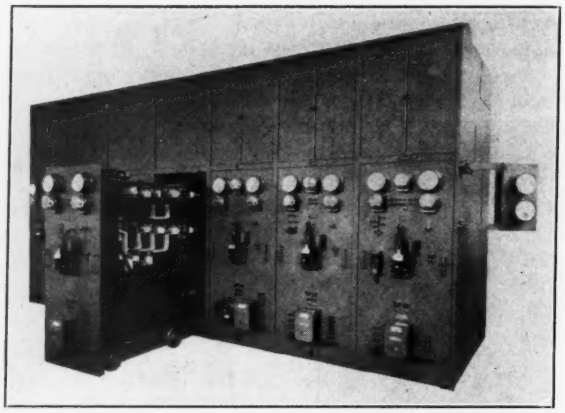
SOLENOID-OPERATED OVAL TANK TYPE CIRCUIT BREAKER DEVELOPED BY GENERAL ELECTRIC CO.





GENERAL ELECTRIC RELAY FOR UNDERVOLTAGE OPEN PHASE AND REVERSE PHASE PROTECTION

GENERAL ELECTRIC OVERCURRENT AND POWER DIRECTIONAL RELAY FOR GROUND FAULT PROTECTION



SAFETY ENCLOSED UNIT REMOVABLE TRUCK PANEL SWITCHBOARD AS DEVELOPED BY GENERAL ELECTRIC CO.

decreases and the contacts open. The disk is slotted so that a snap action is obtained on either closing or opening the contacts.

A relay provided to protect alternating current systems consists of a directional element having a potential coil, a current coil, and a double throw contact member.

The potential coil is connected across the network and the current coil is so connected as to be energized in accordance with the current through the line with the switch closed, and in accordance with the voltage across the switch when the switch is open. The relay operates to trip the switch when current flows from the network to the transformer, whether this current is due to a short circuit, or is only the magnetizing current of the transformer. It operates to reclose the switch when the voltage conditions are such as to cause power to flow into the network.

Two relays were developed for ground fault protection, one of which is shown herewith. This operates on the watt principle obtaining its operating current from the current transformer in the grounded neutral, and from the residual current of the three-line current transformers. The time of operation is obtained from an overcurrent relay connected in either of the two current circuits. The directional element is the same as that in the preceding relay except that no time adjustment is included; it is generally set for very prompt action, relying on the overcurrent element for the time feature.

A typical switchboard made up of safety enclosed, removable truck panels of the new design embodies several improvements, especially in the interlocking features and methods for inserting and removing the trucks from the housings. Several switchboards of this design are installed in power stations and industrial plants in various parts of the country where the potential of the circuits ranges up to 15,000 v. and where 2000 amp. is the maximum required current capacity of the oil breakers, which are mounted on the trucks.

A typical Selsyn signal pedestal has a transmitter operated by hand to transmit signals from the switchboard room to the generator. The attendant upon hearing a bell ring observes that a globe on one of the pedestals is lighted. He then reads on the upper dial that the operator has issued an order. He turns his transmitter handle to the same order which, indicating on the upper dial of the switchboard room pedestal, assures the operator that the proper order has been received and carried out.

Statement by Westinghouse Electric and Manufacturing Co.

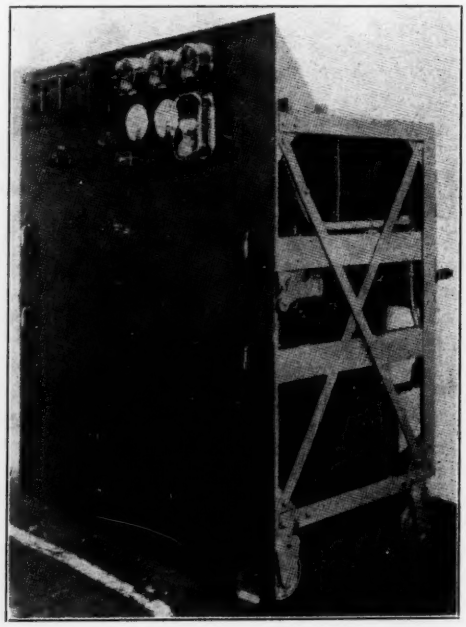
One of the fundamentals which should always be borne in mind in laying out a switchgear equipment is, that the switchgear should not offer an undue hazard to the attendant when called upon to operate it particularly under conditions arising from electrical failure of apparatus or lines. The increased amount of energy that may be sent into a fault because of the steadily increasing concentration of power makes it all the more necessary to safeguard against the disturbances caused by the incorrect operation of electrical apparatus. During the past year the Westinghouse Company has been perfecting its lines of enclosed switchgear as one means of meeting this problem.

For major switchgears in central stations the continued use of segregated or separated phase arrangements with its consequent minimizing of phase-to-phase faults continues to meet with favor.

Where outdoor switching is involved and for voltages up to 33,000 v., considerable attention is being given to the complete enclosing of bus bars and connections to the various switching devices. In this manner the life hazard to the operators, who may be called upon to work around the high tension switch yard on some portion of the switchgear, is materially reduced. Accidental contact with adjacent live circuits is eliminated and the possibility of injury or loss of life to an employe is minimized.

The advantages of steel construction for switchboards are so marked that standard designs of steel control desks have been developed.

Truck-type switching equipments built during the year have included the heaviest units so far constructed.



HEAVY CAPACITY STEEL TRUCK-TYPE BOARD WITH THE OIL CIRCUIT BREAKER AS DEVELOPED BY THE WESTINGHOUSE COMPANY

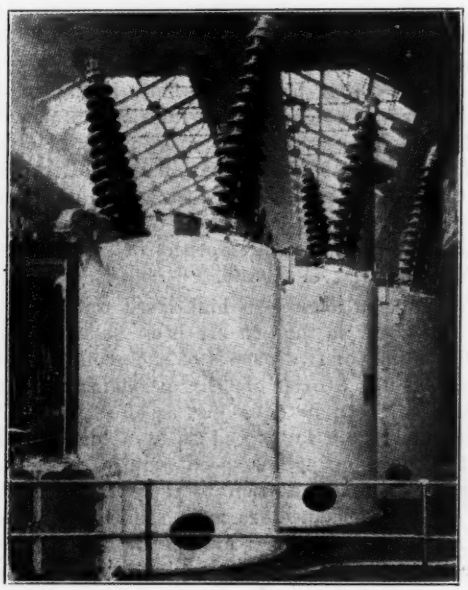
Development of protective devices during the past year has been devoted largely to the mechanical improvement of the wide variety of protective relays manufactured by the Westinghouse Company and intensive studies as regards the application of the various available relays so as to obtain improved operating results.

Among the individual relays that are worthy of particular mention are the type "CZ" impedance or distance relay with the accompanying auxiliary development of suitable compensator devices to reduce the installation expense on the high voltage line, whereby advantage is taken of the low voltage potential and current transformers. Improvements in the detail design of the relay permits of its wider application to certain types of systems.

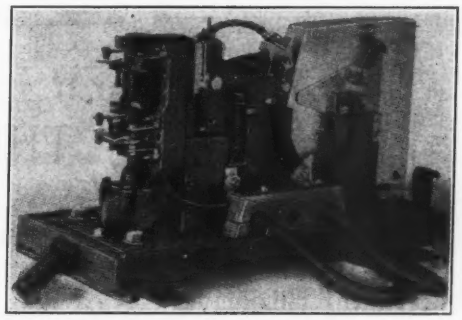
The circuit breaker has attained vast importance and monumental size with the growth of high voltage, high power systems. For example, the largest breakers in the world are rated at 220,000 v., to rupture 2,500,000 kv.a. on short circuit. They are of tremendous size, weighing installed and full of oil 170,000 lb. Oil breakers have been designed and constructed during the past year to rupture 1,500,000 kv.a. at 73,000 v.

A major improvement in oil circuit breaker construction is the development of the high speed contact principle by which the arc opening action of the breaker is speeded up, thus reducing the destructive arcing effect on the oil and contacts. An interesting development in oil circuit breakers is multiple pole breakers with all poles in one tank. This compact construction is especially valuable for truck mounting service since these breakers are the first line of small oil and gas proof switching apparatus developed in this country.

Noteworthy in power house circuit breakers is the type in which the complete breaker with operating mechanism is built in a unit and completely assembled and adjusted before leaving the factory. This breaker has



WORLD'S LARGEST CIRCUIT BREAKERS—220,000-V.—TO RUPTURE 2,500,000 KV.A. BUILT BY THE WESTINGHOUSE CO.



WESTINGHOUSE UM-2-A MAGNETIC LINE SWITCH

condenser terminals, internal pole unit mechanisms and is full automatic in all positions. A line of outdoor remote control disconnecting switches from 7½ to 73 kv. has been developed to meet the requirements of winter operation where snow and sleet are heavy.

An interesting development is a tandem d.c. breaker electrically-operated for transferring feeders from one bus of an Edison three-wire system to another. These breakers operate in conjunction with corresponding breakers in the manholes to sectionalize the system in case of trouble. The tandem breaker is responsive to relay action or control switches at the switchboard.

The demand for dead front switchboards has necessitated a line of back-of-board carbon breakers so arranged that all electric circuits are in the rear of the panel, and the operator is entirely safe in closing or tripping the breaker.

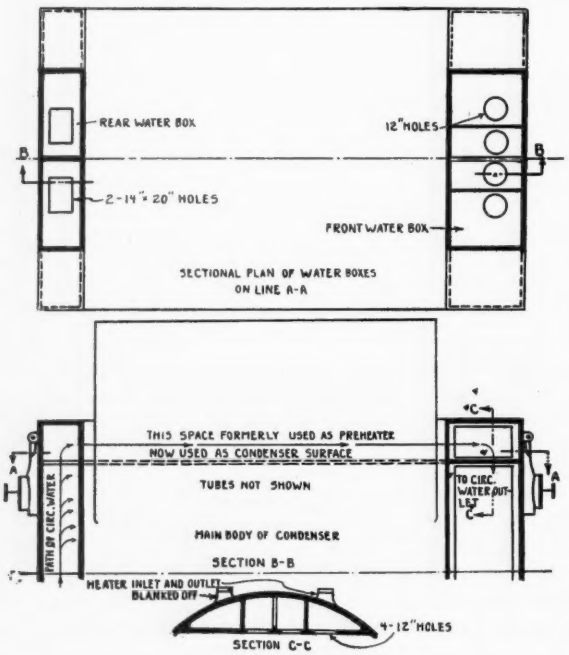
Automatic substation service has required the development of especially reliable and rugged high-capacity, d.c. circuit interrupters capable of withstanding many thousands of operations without maintenance. The Type CH interrupter was tested for durability against a short circuit of 20,000 amp. at 650 v. every 15 sec. for one hour continuously, and at the end of the test was in first-class shape mechanically and electrically.

The "K," or drum, controller, common on street cars, gives much better service if relieved of breaking the main current. For some years there has been considerable use of a "line switch"—a single magnetic or electro-pneumatic unit switch to take the main break, operated whenever the K-controller is turned toward the off position. The usual operating device has been a ratchet switch fitted in the bottom of the K-controller, which required that the drum move backward a definite amount before actuating the line switch. Under certain conditions, heavy arcing might still occur upon the drum.

The new handle switch is operated by lost motion between handle and drum, therefore it acts before the drum begins to move. It still further reduces arcing, and has the mechanical advantage of being in a better location than the ratchet switch. In the same connection, a new magnetic line switch, UM-2-A, has quick action, an improved double coil blowout, and increased capacity for current carrying and arc breaking, without increased cost. Self-alining controller fingers now reduce drum and finger maintenance on various power and auxiliary circuit controls. A new compact fused 10-amp. switch has a coilless blowout and is adequate for all minor 600-v. circuits.

Increasing Effectiveness of Steam Condenser

In a central station power plant where a 35,000-sq. ft. surface condenser was installed in connection with a 20,000-kw. turbo-generator, the circulating water became so warm during the summer season that difficulty



SPACE FORMERLY USED AS PREHEATER NOW USED AS CONDENSER SURFACE

was frequently experienced in maintaining a proper vacuum. The condenser was of a type which had an integral feed-water heater at the top of the shell through which the condensate was passed before going to the plant heaters. It was decided to try the effect of using the heater tubes as additional condensing surface. At the next cleaning period, therefore, holes were cut in the front and rear water boxes as shown at H in the attached sketch, permitting circulating water to flow through the heater tubes. The condensate was piped direct to the plant heaters, the heater connections on the condenser were blanked off and the vent piping moved to the top of the heater space. This proved to be an effectual remedy and no further trouble was experienced in obtaining a satisfactory vacuum.

Philadelphia, Pa. C. F. Fessler.

Waste Caused by Vibration

Vibration is a prolific source for the waste of power. It takes power or energy to set up and maintain vibration in any object or in any machine or other piece of mechanical or electrical apparatus. The ordinary cases of vibration in machinery with which we come in contact are generally unwanted conditions that are brought about by improper adjustment or alinement or balance of the mechanism in question.

Vibration, besides causing the annoyance coincident with humming or other noise, may be the cause of serious and rapid deterioration of the mechanism due to uneven wear of the rotating parts. In addition to this, vibration, by the very deterioration and wear which it causes tends to aggravate the condition still further and unless remedied in a reasonable period of time may result in an explosion of the rotating member of the mechanism or in other serious consequence.

Serious vibration may be present in a rotative mechanism which is not discernible by ordinary means such as placing the hand upon the machine or by standing near it. Many times it may be noticed that at certain speeds there will exist a distinct vibration in a machine which is quite perceptible to a person standing near it or leaning against it, while at other speeds this vibration seems to disappear. The disappearance of the phenomenon is not, however, the cessation of unbalance and strain within the machine caused by the faulty condition, but is simply the disappearance of the outward evidence. The same deteriorating forces of unbalance are still at work and in all probability to a far greater degree than before, especially at higher speeds, but the outward evidence of their existence, namely the sensible vibration of the mechanism, perceptible as such to the observer, has disappeared due to the fact that the vibrations of the rotative member are not in step with the natural period of vibration of the frame of the machine and are thus dampened or prevented from causing the frame to vibrate.

In balancing a piece of high-speed rotative machinery, the proper method to use is to balance it at low speed. If the rotative part is of such construction and design that it is capable of being permanently balanced, the balancing can be done just as effectively and just as accurately at a low speed as at a high speed. In fact the balancing at low speed requires less time and less power and in addition to these facts the indications due to unbalance are more reliable at low speeds than at higher speeds. At low speeds, also, there is less chance of either distortion or whipping interfering with the accuracy of the results.

Considerable attention is often paid to the matter of balancing crankshafts but the matter of the balance

of flywheels, clutches and pulleys connected to the crankshafts is too often disregarded. A castiron flywheel or pulley is likely to be badly out of balance, or even a forged steel wheel is often liable to cause trouble due to its unbalanced condition. The crankshaft and the flywheel should be balanced separately, it is not generally necessary to check the combination if the fitting is accurate. It is not good practice to bolt the shaft to the wheel in an unbalanced condition and then balance the combination.

In designing counterweights the greatest of care must be exercised not deliberately to defeat the purpose in view, namely the balancing of the mechanism including the rotating parts. In the case of an engine all attempts to over-counterweight the shaft, presumably to correct for the action of the connecting rods, will not be successful.

In too many cases when investigations are conducted after the failure of high-speed machines, it has been customary to look for the cause of the trouble in such remote agencies as crystallization and fatigue of metals, original defects in workmanship including construction and erection, careless methods of starting and stopping the machine or other faults of operation and maintenance, instead of investigating from the standpoint of the most definite and fundamental reason for the failure or explosion, namely excessive vibration. Vibration is the symptom of an unhealthy condition existing in any piece of machinery, especially in high-speed rotative apparatus and such condition should not be tolerated or neglected but should be properly and promptly remedied as soon as it makes itself known.

Los Angeles, Calif. C. C. BROWN.

Steam Waste

DURING the past 20 yr. the power plant journals have printed many articles in an effort to teach engineers and plant owners that a great loss is sustained when exhaust steam is allowed to be wasted. Any person can observe in any large city, particularly on a cold day, the many streams of steam escaping into the atmosphere.

High-pressure engines are still common in factory and office buildings for operating elevators and other works. Suppose such an engine were to exhaust into a heating system, at say 2 lb. pressure, the back pressure would have a total heat above 32 deg. of 1148.9 B.t.u. The average temperature of the feed water without a heater may be assumed to be 55 deg. Therefore we have 1148.9 — (55 — 32) = 1125.9 B.t.u., as the net saving for each pound of steam thus saved. Suppose the heating system required 4000 lb. of steam per hour to maintain the required temperature in the building and the coal used evaporates 9 lb. of water per lb. of coal. At the above-mentioned temperature of 55 deg., 4000 ÷ 9 = 444.4 lb. of coal would be saved each hour. The above is only approximate, but it is sufficient to emphasize the fact that any engineer knowing such facts should bring the matter to the attention of his employer.

Many years' experience has convinced the writer that most power plant owners are more than willing to listen to suggestions for saving money, when the engineer has more than mere words to offer. Take your employer to the window, show him the clouds of wasted steam, then clearly present to him easily understood figures showing the possible savings. Remember that the vast majority of owners are not engineers, many of them do not realize that exhaust steam passing through an engine has given up only a portion of its heat units. When this is fully presented to him, he will, as a rule, take measures for saving much of the steam that is being wasted. He may call in outside advice and have plans drawn up. That, however, is his own affair. Even in this case he will realize that his own engineer has his employer's interest in mind, and anything an engineer can do to further his employer's interest will also generally react to the engineer's benefit. Wasted steam and dirty boilers are two of the greatest money eaters in a steam power plant.

Toronto, Canada. EDWARD JAMES.

Keeping Healthy

ALTHOUGH the spirit of an employe may be willing, it avails little, if the flesh is weak. Individual efficiency in industry depends on the development and maintenance of sound minds in sound bodies and many progressive firms have adopted plans for supervising the health of the personnel.

Physical examination prior to employment insures the selection of workers who will be physically able to do the work and prevents the placing of men with poor vision, weak hearts, contagious diseases and other disabilities in positions where these defects may result in injury to either the worker or his fellows. From an economic as well as a moral standpoint, it is imperative that only suitable men be employed.

In addition to the initial examination, periodical inventories of the worker's health are conducted by an ever increasing number of firms. One company reexamines the important members of its personnel every six months, although in the majority of cases, annual examinations are considered sufficient. Cost of such physical examination, if the volume of work is large enough to justify a full-time physician, is estimated at something less than $1 a man. On a part-time basis, which is the usual arrangement for smaller plants, this cost is proportionately reduced.

First aid equipment for the treatment of minor injuries should be found in every plant.

In the Central Manufacturing District of Chicago a unique arrangement has developed among a group of small industrial plants whereby each is provided with medical assistance at a minimum of cost. In this group of plants, a good doctor, with a leaning toward industrial practice, has established himself on a "syndicate" basis. His "clients" are the companies and each pays him a retaining fee based on the number of men employed. In return, he makes periodical visits to each shop, doing the usual work of examining teeth, eyes, throats, skin abrasions, or making physical examinations and medical recommendations either to the management or to the individual man. His office is located in the convenient center of this group of plants so that he is constantly on call by any one of them in the event of an emergency. Such an arrangement provides small plants with expert assistance at small cost and enables the physician to keep constantly in touch with upwards of 400 men from whom can be developed a reasonable private practice. So advantageous is the plan to all

concerned that the companies frequently are permitted to lower the retainer fee after the first year or two, if they so desire.

In keeping healthy employes healthy, recreational activities such as athletic associations and the like, are excellent allies. In some industries, rotation of jobs has been found advantageous. As an example, an employe whose duties expose him to excessive heat, fumes or gases can be detailed to perform other work that will occasionally bring him to the outdoor atmosphere, where such shifting is possible.

Doing everything possible to keep workers healthy is both a dollars and a sense proposition.

Chicago, Ill. WILLIAM SIBLEY.

Education for the Power Plant Engineer

JUST AT PRESENT a lot of letters are being written and printed in reference to college educated and other engineers. To be a success as a chief in a stationary power plant, several things are necessary. A college education is not one of these things; but the chief should be a mixture of go-aheadness and hold-backness; that is, he must stick to some of the old ways of doing some things and at the same time be alert to learn as *much* as possible of what is new and has a savor of advance.

To stick to old methods and practice in power plant operation results in one's being left in the lurch as a bas-been, but to adopt everything new that presents itself will quickly relegate as a failure the chief who attempts it. What is necessary is to sift out the good and reject the worthless; this is the kind of problem a successful chief must be able to solve.

Because he possesses the faculties of perceiving what is useful and what is worthless for use in the plant he has charge of and knows how to use the things that are really useful, a man attains success in power plant work.

Almost any intelligent man who has a liking for power plant work can be educated to it. To really be an engineer, a man should possess certain characteristics, the most essential being that of a thinker, who therefore is able to reason clearly from cause to effect and, instead of sitting down like Micawber and waiting for something to turn up, he makes the best of things, determines ways and means and forces desired results by the use of material at hand. Such men usually have an aptness for the work and such a liking for engineering that they regard it above every other kind of work.

Some men will get better results from a plant than will others; possibly such men are "fittest" and will reach the top first. They succeed better than we do because of the use they make of the materials at their hand and of the brains with which they are endowed. We might do as well were we to think more and study better methods for operating our power plants, and were we to be always ready and prepared to grasp an offered opportunity. There never has been a better chance for advancement of power plant engineers than is now available, with the many low priced but high class engineering journals and text books now on sale. Education in engineering is available to every man who is willing to study; very little money is necessary.

There is absolutely no excuse today except laziness for the ignorant stationary power plant engineer.

Toronto, Canada. JOHN THORN.

Length of Crossed Belts—Discussion

THE ARTICLE by W. F. Schaphorst, under the title given above and published on page 1280 of the December 1, 1926 issue of Power Plant Engineering, dealt with crossed belts alone. The formulas given below may be used to determine the length of open and crossed belts, and are much simpler, because they do not require the extraction of the square root nor involve any multiples of the number 3.1416:

For Open Belts:

$$L = 2C + \frac{11D + 11d}{7} + \frac{(D - d)^2}{4C} \qquad (1)$$

For Crossed Belts:

$$L = 2C + \frac{11D + 11d}{7} + \frac{(D + d)^2}{4C} \qquad (2)$$

in which all dimensions are in inches, and

L = length of belt;
D = diameter of large pulley;
d = diameter of small pulley;
C = center distance between pulleys.

For example: If the dimensions for a crossed belt are: D = 20 in.; d = 10 in.; and, C = 100 in.

By substituting in Formula (2), we get

L = 249.39 in.

By exact formula we find the length to be 249.38 in.

Cleveland, Ohio. WILLIAM W. JOHNSON.

Making One Reason Sound Like a List of 'Em

PAT IS a first-class engineer and he is also a first-class talker. Because of his ability to talk, even though a great deal of it is "bunk," he usually manages to get whatever he feels that his plant needs.

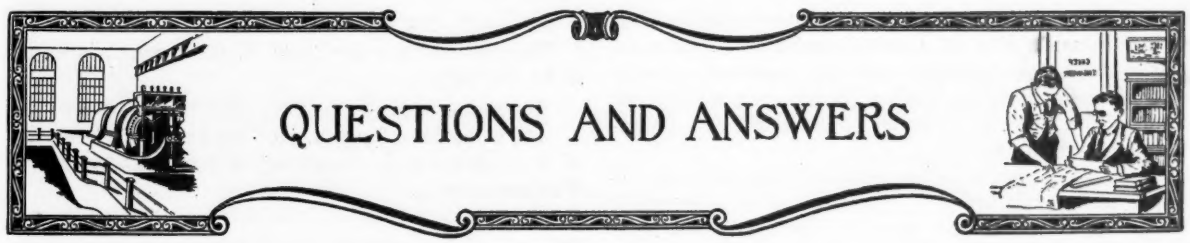
He wanted a feed-water heater and this is the way he got it. "Mr. Murphy," he said, "from the standpoint of coal consumption alone there are four good reasons why we need a feed-water heater: First, we won't use so much coal in a year; Second, we will get more power out of each pound of coal; Third, the theoretical and actual heat efficiency will be higher all around, and Fourth, a great deal of money will be saved on coal. In all there are 'tin' reasons. If you want more reasons I will tell you them. Another reason, there's a big saving in coal on account of taking scale out——."

Murphy stopped Pat right there. "We'll get one immediately, Pat. Why didn't you tell me about this before?"

That night Pat told his wife how he did it by making one good reason sound like a list of 'em. "But don't tell anybody, Mary. I don't want Murphy to git wise to me curves."

Newark, N. J. W. F. SCHAPHORST.

FOR EVERY piece of equipment a history file should be maintained, starting with a 5 by 7-in. card when the item is received and installed. Every inspection and repair should be completely recorded on this card, thereby providing a valuable history of the service of such equipment. This data will prove of great assistance to the plant executive at a later date when replacement of equipment is being considered, or when plant additions are being contemplated.



QUESTIONS AND ANSWERS

Water Backing Up Into Engine

WILL YOU NOT put the following question to the readers of Power Plant Engineering:

"What causes water to back up into a steam engine while it is running, causing it to be wrecked; the engine being connected to a barometric condenser set 34 ft. above the hotwell?"

This is said to have actually happened in one Massachusetts plant, and it is reported that no engineer will be granted a first-class license until he can answer the question correctly. C. L. P.

Editor's Note: We shall be glad to receive comments and solutions from our readers on the above question.

What Put the Hump on the Card?

TO GIVE THE correct analysis of the card illustrated on page 1346 of the December 15 issue of Power Plant Engineering, more information is needed. What type of engine is it? I presume it to be a Corliss engine operating at a fairly high rate of piston speed. If it is a single eccentric engine, then move the eccentric ahead on the shaft one inch in the direction that the engine turns. If it has a standard Corliss gear, then shorten the connecting link between the wrist plate and the bell crank so as to increase the lead on the crank end. The little hump on the crank end will then disappear.

All high piston speed engines have from 1 to 5 lb. higher initial pressure on one end of the cylinder than the other. This is due to the surge of steam in the steam pipe from the boiler to the engine valves. Kinetic energy is built up when one steam valve is open and as it instantly cuts off, the surge or velocity of steam continues, then rebounds, and as the rebound starts back toward the boiler the other steam valve opens, and before it can close the opposite surge of pressure does not have time to build up to the initial as shown by the other card.

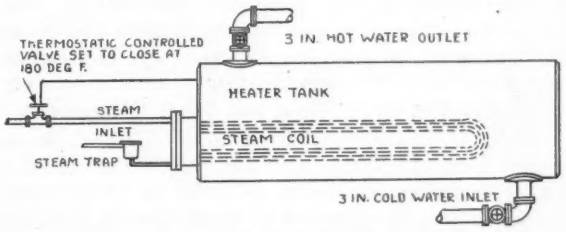
Chicago, Ill. J. P. GREENWOOD.

Bursting of Water Heater Due to Built-Up Pressure

OUR HIGH pressure hot water heater, illustrated in the accompanying figure, burst along the welded seam, after a service of only about 30 days. Our boiler pops at 100 lb. per sq. in. and our water pressure is 50 lb. The heater was tested to 100 lb. per sq. in. Why should the heater burst under these conditions and how much pressure could be exerted in this tank with water at 50 lb. per sq. in. and a temperature of not more than 190 deg. F. if the valves shown in the figure were closed? How much pressure could be exerted in the water if the steam coil had the full 100 lb. per sq. in. steam pressure in them and the valves were closed, and the water pressure surrounding the steam coil is 50 lb. per sq. in., the water on entering the tank being cold?

F. R. W.

A. The pressure in the steam coils is not communicated to the surrounding water. If, however, steam is admitted into the coil after the tank has been filled with cold water and the water valves all closed, the heat from the steam, communicated to the water, may cause the water to expand sufficiently to burst the tank.


THERMOSTATIC CONTROLLED VALVE SET TO CLOSE AT 180 DEG F.
3 IN. HOT WATER OUTLET
HEATER TANK
STEAM INLET
STEAM COIL
STEAM TRAP
3 IN. COLD WATER INLET

ARRANGEMENT OF CONNECTIONS THAT RESULTED IN BURSTING OF HEATER

It is also possible that your thermostat may not have been operative and the actual temperature under this condition built up higher than 180 deg. F.

Another possibility is that the water pressure was actually much in excess of 50 lb. per sq. in. You do not indicate the installation of a relief valve which would have indicated excessive pressure and prevented bursting of the heater.

Our impression is that the cause of the rupture was due to one or more of the above-mentioned causes.

Thickness of Boiler Scale vs. Boiler Efficiency

CAN YOU furnish me with results of tests on percentage amounts of fuel required under boilers for different thicknesses of boiler scale formation?

G. S. N.

A. Until recently, tests to determine the effect of boiler scale formation on the heat conductivity of boiler tubes, considered the effect to be proportional to the thickness of scale. No series of tests appear to have been made, however, under conditions in which the thickness of scale alone varied while the other conditions of operation such as water supply, remained constant. Recently Dr. S. W. Parr, of the University of Illinois, in a report prepared for the Joint Committee on Fuel Conservation of the American Railway Association, pointed out the results of a number of tests and showed that the relation between varying thicknesses of scale and heat losses was not uniform.

Dr. Parr also refers to investigations made by Professor Schmidt, also of the University of Illinois, in which the latter concludes that the structure of scale as well as its thickness has a vital influence on its heat conductivity. Professor Schmidt summarizes his investigation as follows:

1. Considering scale of ordinary thickness, say of thickness varying up to ⅛ in., the loss in heat transmission due to scale may vary in individual cases from insignificant amounts to as much as 10 or 12 per cent.

2. The loss increases somewhat with the thickness of the scale.

3. The mechanical structure of the scale is of as much or more importance as the thickness, in producing this loss.

It is thought that a third influence on the loss of heat conductivity may be due to the composition of the scale after it has been baked on the tubes. Both compostion and structure doubtless affect the heat conductivity.

If the heat conductivity were constant, increasing thickness would indicate decreasing conductivity. But Dr. Parr's report indicates that while there can be no doubt of a loss of heat due to scale there is disagreement as to the large losses frequently claimed for very thick scale, that is for ¼-in. and ½-in. thicknesses.

While it is known that scale of ⅛-in. thickness formed from one source of water supply may cause a loss in heat transmission of as much as 12 per cent, conditions have been known in which deposit filled the tubes so full that a lead pencil could scarcely be pushed through the opening in the center of the tube, without greatly reducing the heat transmission.

Heat transmission of boiler tubes is affected not only by the thickness of the scale but also by the composition and structure of that scale.

Flow of Water in Pipes

IT IS PROPOSED to run a 2-in. steel pipe line with fairly smooth interior surface a distance of 3 mi., the pressure at the hydrant where this line is to be connected is 38 lb. per sq. in. Assuming that the elevation where the pipe terminates is the same as at the hydrant, what will be the discharge from this line in gallons per minute?

Also, what would be the discharge if the line terminated at a point 20 ft. lower than the hydrant?

S. R. B.

A. The formula for determining the quantity of water that will flow through a given pipe under various pressures is

$$Q = c\,a\,\sqrt{r\,s}$$

where

Q = quantity of water in cu. ft. per sec.

c = contraction coefficient, determined from experiment.

a = area in sq. ft. of pipe cross-section.

r = mean hydraulic radius (area of wet cross-section divided by wet perimeter).

s = slope = H ÷ L.

H = pressure head in ft. water.

L = length of pipe in ft.

$H = 38 \times 2.3094 = 87.76$ ft.

Fall in ft. per mi. = 87.76 ÷ 3 = 29.25.

The value of $\sqrt{s}$ for 29.25 ft. fall per mi. is found to be 0.07436.

The value of $a\sqrt{r}$ for 2-in. pipe is 0.004836.

The value for c for 2-in. pipe for an assumed velocity of 1 ft. per sec. is, according to best authorities, 94. We then have

$Q_f = 94 \times 0.004453 \times 0.07436 = 0.0338$ cu. ft. per sec.

The discharge in gallons per minute will then be

$Q_g = 0.0338 \times 60 \times 7.48 = 15.17$ gal. per min.

If the discharge end is 20 ft. lower than the hydrant the total head will be 87.76 + 20 = 107.76 ft.

Under these conditions the discharge in cubic feet per second will be $94 \times 0.004836 \times 0.0824 = 0.0375$ and the discharge in gallons per minute, $0.0375 \times 60 \times 7.48 = 16.83$.

The above calculations are based upon smooth straight pipe with no obstructions and consider the pressure given at the hydrant as that of the pipe itself.

Loss of head which would correspondingly affect the quantity of discharge may occur due to

a. Contraction at entrance.
b. Sudden enlargement of area.
c. Sudden contraction of area.
d. Turns, such as in elbows, bends or tees.
e. Obstructions as in valves.

Change of Altitude and Back Pressure

WILL YOU please tell me what effect high altitudes have on steam engine performance and what is meant by "back pressure"? J. S. H.

A. Back pressure is pressure built up at the discharge end due to atmospheric pressure and pressure due to forcing the exhaust steam through the valve ports, passages and piping. Condenser action, by rapidly reducing the volume of discharge steam through condensation, reduces back pressure. Reduction of back pressure increases the amount of effective work of the engine.

Change of altitude has no effect upon the net performance of a steam engine because the difference in atmospheric pressure acts in the same way upon the initial steam gage pressure as it does on the back pressure, increasing both in places of low altitude and reducing both in cases of high altitude, provided, of course, the absolute pressure remains the same. The effective work is the same in any case.

Zeolite Method of Treating Boiler Water

PLEASE LET me know what softening water for boiler feed by the "zeolite process" is. F. V. G.

A. This process consists in passing the water through a filter bed of zeolite gravel during which sodium is exchanged for calcium and magnesium. Sodium salts are harmless, while calcium and magnesium sulphates form extremely hard scale. It is claimed that after treatment by the zeolite process, the water contains no hardness and no deleterious minerals.

After being used for treating a quantity of boiler water, the zeolite bed may be regenerated, that is,

brought back to its original state by passing through it a solution of common salt dissolved in water. It is claimed that in this regenerative action, no loss of the zeolite bed is involved.

Steam Velocity in Turbines

IN THE steam turbine is the velocity the same in all stages?

2. How is the velocity determined?

3. Why should the velocity be greater in the lower stages?

4. How can a Corliss engine be made safe to run with the governor stop pin in place? L. E. D.

A. 1. Velocity is not the same in all stages of a steam turbine as the velocity depends on the pressure drop allowed per stage and this is entirely at the control of the designer. If he makes the pressure drop the same in all stages, the velocity will be a good deal higher in the low stages than in the igh.

2. Velocity in the steam turbine is attained by allowing the steam to expand through properly shaped nozzles from a higher pressure to a lower, the effect being the same as blowing a steam jet into the air, except that the expansion is carefully controlled so as to get the most economical results. The pressure drop allowed in each stage in the reaction type of turbine is comparatively small, while in the impulse turbine, the pressure drop and resulting velocity in each stage are large.

3. Velocity attained in any stage depends on the heat energy given up because of the drop in pressure and the turning of this heat energy into velocity energy. The heat energy given up depends on the difference in the total heats at the two pressures and the difference in entropy at those pressures. There is not space here to go into the matter of why this is s . Velocity in any stage can be made any desired amount by the pressure drop allowed.

It is customary and more convenient to keep the pressure drop in the various stages about the same and this results in a much higher velocity in the low stages, because for a drop of 1 lb. at 200-lb. pressure, the difference in total heat is 1/10 B.t.u., while a drop of 1 lb. at 15-lb. pressure gives a difference in total heat of 1 B.t.u. There is also the mechanical construction of the blades to be considered. For high pressures the increase in volume of steam is comparatively small for a given pressure drop, while at the low pressures this becomes increasingly large. As an example, for one type of 3-stage turbine expanding from 165 lb. absolute to 1 lb. absolute, the energy given up in the first stage is 2.03 B.t.u., in the second stage 4.06, and in the third stage 8.13 per lb. of steam. For the same turbine the volumes at the beginning of each stage are in the proportions of 1 to 3.1 to 9.61. Blades would have to be extremely long to pass low pressure steam unless high velocities were used.

4. Since the governor stop is provided as a safety precaution, why should any one want to try to run with it in? The stop pin is provided simply to hold the governor up while the engine is starting and should be removed as soon as the engine is up to speed so that, if the governor belt breaks, the governor balls will drop and cut off all steam from the engine.

As a secondary precaution, however, a rider pulley may be placed on the end of an arm and arranged to ride on the governor belt with either mechanical or electrical connection to the arm so that, if the governor belt breaks, the pulley will drop and cause the main steam valve to close.

Some Hoisting Data

I AM CONFRONTED with a hoisting problem in which I lack the following information for which I would be greatly thankful if you could supply it to me:

What is the safe lifting load of ½-in., ⅝-in., and ¾-in. best grade manila hemp rope?

What is the smallest diameter drum upon which each of these sizes could be safely wound and unwound continuously without danger of breaking the fibers to such an extent that the rope would be materially weakened? A. A. G.

A. Dia. rope	Safe lifting load	Minimum allowable dia. of sleeve
½ in.	50 lb.	18 in.
⅝ in.	78 lb.	22½ in.
¾ in.	112 lb.	27 in.

Centrifugal Pump Operation

WILL YOU please answer the following question:

If a centrifugal pump is set below the water line and pumps water about 50 ft. high, which is the better procedure, to have the discharge line open or shut? F. R.

A. It is better to shut off the discharge line until the pump has attained its normal speed, then gradually open the discharge line. In this case the water in the pump is simply churned up; the pump does no useful work until the discharge valve is opened, after which both suction and discharge function. The pump is thus relieved of its starting load until it is "up to speed."

Care should be taken not to run the pump too long with discharge valve closed, because the churning action heats the water and in time the water may also be impregnated with air bubbles.

Single-Stage vs. Multi-Stage Compression

DETERMINING the dividing line between single and two-stage compression is not exact as there must, of necessity, be some overlapping due to different conditions.

For pressures up to 60 lb. per sq. in. gage, single-stage compression should be used. Between 60 and 100 lb. per sq. in. gage the decision between single and two-stage compression will depend largely upon first cost, capacity required, cost of power, altitude and whether or not the installation is to be permanent.

There is no doubt that multi-stage compression is more efficient where the pressure is over 60 lb. although the use of a single-stage machine may be advisable for economic reasons. Single-stage machines may be used even with pressures as high as 110 lb. for displacements of less than 350 cu. ft. per min. Multi-stage compression for permanent installations requiring more than 100 lb. pressure and displacements of over 300 cu. ft. per min. is generally advisable. Standard two-stage compression pressures range from 100 to 125 lb. gage.

EDITORIAL COMMENT

Weird Cost Distribution

Profit making is the objective of every business. To continue to make a profit, a business must render a service which its patrons find worth paying for, otherwise patronage and income will decrease.

Nearly all businesses have several departments and use every effort to have each one show a profit. It may be worth while to carry on a department which is not paying its way because of the benefit to the business as a whole, but it should be done knowingly and the loss carried as an overhead, not charged to other departments.

Sane operation of government departments would be a like procedure. Nobody expects the Army or the Navy Departments to show a profit or that Congress will earn an income. Such activities are carried on for the good of the country. The same is true of all governmental activities with one exception. Some government officials seem to feel that the Post Office Department should pay its own way, probably because it does have an appreciable income, yet these same officials load the Post Office with a lot of service for other departments, which involve a large expense and for which the Post Office Department gets no return. There seems no good reason why the mails should carry a lot of matter for Congress or for other departments and then have the expense of such service charged as a deficit against the Post Office. But it is done. It is estimated that the cost thus unfairly dumped on the Post Office Department by other government agencies is $15,000,000 a year.

Foreign mail is handled at a heavy loss, some $5,000,000, which goes into Post Office deficit although it is really a subsidy to promote foreign commerce.

Air mail routes are maintained largely to encourage aeronautics. They are not an essential to postal service and do not have enough patronage to pay for the cost of operation by $2,000,000. Although they are at times a convenience, the purpose could be served by telegraph and telephone in most cases and at less total cost than the air mail involves.

Cost should be allocated to those services which make them necessary. Rural free delivery, which was established to ameliorate the conditions of farm life is not essential to most classes of mail. It adds to the comfort of those it serves as do parks and playgrounds and is worth while as a service to the country but, except for first class mail and some parcel post matter, the time saving in delivery and despatching is not important. Also, in the present day of automobile operation of routes, large costs are incurred, in order to give jobs to political workers, which are unnecessary. It may be difficult to determine against what government activity such needless expense should be charged but certainly there is no reason why it should be carried as a "postal" deficit. It is estimated that economical handling of the R. F. D. service could save $50,000,000 a year but Congress has blocked the way to such management by limiting the length of R. F. D. routes.

Special rates to fraternal, religious and scientific society publications, granted as an aid to culture and social intercourse, account for a loss of $11,000,000 while franked mail, "free in county" mail and star routes are responsible for some $17,000,000 expense.

Altogether, it is estimated that expenses which have nothing to do with the primary purpose of the Post Office service will total $140,000,000 a year and these should be eliminated or charged to the departments and bureaus or services in whose interest they are incurred.

As to allocation of cost within the Post Office Department, the same principle applies. First class mail is said to show a profit of $80,000,000 a year but it is charged with costs of operation only in proportion to its weight. Other classes of mail do not require five to seven deliveries a day or subsidized fast express trains. Freight rates on sand and scrap iron are not the same as on automobiles, furniture and perishable food products. Books, periodicals, circulars do not require the fast service needed for business letters and the last named should carry the expense which they create.

Even though, to make up a train, a car of paper may be hauled along with a car of oranges, the freight rate of each is based on the needs of services. Like conditions may cause parcels, journals and letters to travel in one car but that does not justify extra charge against the more humble material for unnecessarily expensive methods of handling.

In government and municipal activities the tendency is to inaccurate cost keeping, since the public pays for any losses and can usually be expected to forget details. It is time that good sense and business methods be applied in discussing, analyzing and planning the activities of the Post Office Department.

Instruments as an Investment

Instruments are manufactured and placed in position for the definite purpose of being used. If these instruments are allowed to deteriorate or are retained in operation when they are not accurate it is as bad or worse than having no instruments. They are not only taking up valuable space, wasting money in a useless investment, but are building up a false and sometimes dangerous sense of security.

It is inconceivable that a man who would not think of buying half a dozen horns for his automobile will think nothing of buying a dozen instruments of various kinds, makes, shapes and purposes and then, allowing them to go to waste in his plant, flatter himself that he is a progressive, up-to-date engineer.

Fortunately there is a boiler inspector to check boiler

gages, but others not being a life and death matter, are left to the ability or gullibility of the engineer. If he is a conscientious fellow he will make them pay for themselves; if not, he will regard their records with the childlike faith an old lady places in a dollar alarm clock or as something to impress visitors with, as the case may be.

Manufacturers are conscientious in their effort to make accurate foolproof instruments and have them installed properly. No man-made machine will, however, give continuous accurate service without attention and in spite of specific printed instructions many will be improperly located or assembled.

Some manufacturers have already realized this and in addition to their service men have salesmen qualified to adjust and calibrate their equipment and explain its use to the users. Even though the engineer may take little interest, there is usually somebody willing to take over the responsibility and keep the equipment working if given the opportunity.

A further extension of this policy by other companies will add materially to the usefulness of instruments, the efficiency of plants and elimination of investments which now offer no return on the money represented.

Off Duty

It is fortunate for us, no doubt, that in our daily life—in our use of the thousand-and-one conveniences which a beneficent civilization has placed at our disposal, we are unconscious of the fundamental laws which govern all our activities. For, though we may not know it, every action, everything we do, the very growth of our bodies is in some way connected with laws of a mathematical nature and, if every time we picked up the telephone or sat down to a meal, we should be forced to consider these laws, life would be indeed a burden.

Yet, notwithstanding our indifference, mathematics seems inextricably interwoven into our existence. From the time we begin life as a single cell until the day when the life insurance companies finally write us off their books we are enmeshed in a web of differential coefficients and integral signs from which there is no escape.

Take that mysterious number Pi, for instance. This number, which every schoolboy knows, expresses the relation between the diameter and the circumference of a circle, is in some profound way bound up with our destinies, for it makes its appearance in the most absurd places outside of the circle. Some years ago on this page we told how Pi might be determined by repeatedly tossing a stick across the boards of a wooden floor. Another mysterious number is 2.718, to which the mathematician has assigned the symbol ϵ (pronounced epsilon). This number has to do with the compound interest law, which is used in banks but it has a more fundamental significance than anything connected with a savings bank. It also is involved in the growth of living things; the growth of a plant can be expressed by this number. Yet what does a plant know about compound interest?

Again, suppose we consider the theory of probabilities which probably has a more profound bearing on our lives than anything else we can think of. Take, for instance, the simple act of getting on or off an elevator in an office building. If a certain number of people get on an elevator, what is the probability that all of them will get off at, say, the tenth floor? Or, what is the probability that, when ten people enter the car at the main floor, one will desire to leave the car at each floor up to the tenth? Offhand, these questions may seem like so much foolishness, since it may be argued that they cannot be answered without knowing the individual desires of the passengers. And for just ten people this would be true—the questions could not be answered with any degree of certainty. If, however, instead of just ten persons we consider thousands, or tens of thousands of persons, we can answer these questions quite accurately by merely applying the calculus of probabilities. Look at this, for instance:

$$S_n = m\left[1 - \frac{1}{n}\left\{\left(\frac{P-P_a}{P}\right)^n + \left(\frac{P-P_b}{P}\right)^N + \ldots + \left(\frac{P-P_n}{P}\right)^N\right\}\right]$$

Rather formidable, isn't it? This is merely a way of indicating the probable number of stops of an elevator in an office building. It is one of the equations used in the design of modern elevator systems and shows to what extent the theory of probabilities is being used in this work.

This theory is used in many other fields, however. In a telephone exchange, for instance, a certain number of calls fall at random in a certain interval of time. As the calls fall, they are automatically counted by a meter. This meter cannot function properly if the time interval between two calls is less than a minimum time interval. The question confronting the telephone engineer, therefore, is what is the probability that a correct count of the calls will be made? So he applies the theory of probabilities and is able to include correction factors in the meter reading which give him the exact number of calls made, even though the meter did not count all of them.

Another example. Consider a million persons of a certain age. How many of them will die at the age of fifty? At sixty? At seventy? At eighty? By means of statistics and the theory of probabilities, the life insurance companies can answer these questions with uncanny accuracy.

Thus it is that a branch of mathematical science, born in a gambling den, mysteriously controls our destinies. It has been found capable of dealing with the most varied classes of more or less random phenomena, which, from craps to atomic structure, make up the detail of this world. It predicts the fall of the dice in an alley crap game as it does the possibility of our planet colliding with another. Since the time of Laplace it has been the foundation of astronomical research. It is the basis of the kinetic theory of gases and Planck uses it in his theory of radiation. Finally, taking a more romantic example, the very answer of the girl to whom we make love in the moonlight is governed by the calculus of probabilities.

Yearly Index

INDEX for Volume XXX of Power Plant Engineering is now prepared and will be sent free to subscribers upon request.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Clamps for Outlet and Switch Boxes

CHICAGO FUSE MFG. CO., Chicago, Ill., is now furnishing Union outlet boxes for sheathed and metallic cable or loom with a new type of clamp which is tightened after the box is installed. The box is hung

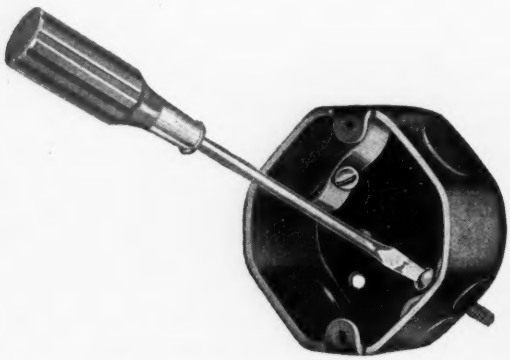


FIG. 1. UNION OUTLET BOXES HAVE NEW TYPE OF CLAMP TIGHTENED AFTER INSTALLATION

in the usual way with or without bar hangers; the cable or loom is brought through the knockouts, pulled up tight and the clamp is then screwed down. The screw heads are on the inside of the box and with the clamps are placed diagonally, as shown in the illustration. The angle is such that the screw heads are easily accessible

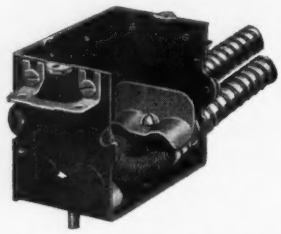


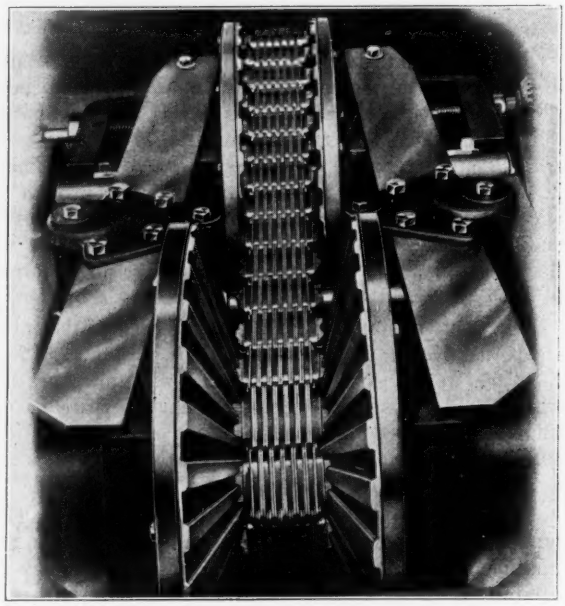
FIG. 2. NEW CLAMP FOR SWITCH BOXES HAS RIGHT ANGLE FLANGE

to the screw driver in all boxes, including those with bushing plates. In boxes 1½ in. deep, the diagonally-placed clamp will fasten the loom or cable whether it enters from the knockouts in the bottom or from those in the side.

This company also announces a new type of clamp furnished regularly with its standard sectional switch box type XC; bracket switch box, type Gem XCB; and Locktite switch box, type Gem XCT. These boxes take sheathed or metallic cable or loom. The new type clamp is known as the No. 7. It has a right angle flange and when the clamp is placed over the cable or loom this flange effectively closes the opening.

P.I.V. Gear Provides Continuously Variable Speed Ratios

DESIGNED TO PROVIDE continuously variable speeds between driving and driven shafts, a new and interesting type of mechanical drive has recently been put on the market by the P.I.V. Gear Syndicate,



THIS SHOWS HOW THE LAMINATIONS ARE FORCED INTO THE SLOTS BETWEEN THE TEETH OF THE CONES AND HOW INFINITE SPEED CHANGES ARE PRODUCED BY LATERAL MOVEMENT OF THE CONES

Ltd., London. This apparatus consists of a box in which two pairs of opposed conical disks are mounted on shafts, one on the constant speed shaft of the gear and the other on the variable speed shaft. These opposed disks are arranged to slide axially on their respective shafts. Power is transmitted from one shaft to the other by a chain of special construction, as shown in the illustration, which wedges in the V formed between the opposed disks and runs at a diameter depending on the axial distances separating the disks.

A lever mechanism actuated by a small handle from the outside of the gear box controls the axial move-

ment of the cones and causes one pair to approach and the other to recede, as desired, thus defining the gear ratio of the box.

Contact between the chain and the side of the cones is made on pads built up of a large number of close-fitting laminations which project through the links of the chain. The laminations are capable of a small movement across the width of the chain, enabling them to accommodate themselves to the radial teeth cut on the working faces of the cones.

The teeth on the cones are wedge-shaped and tapered and are staggered so that as the chain enters the V the teeth on one disk cause an appropriate number of laminations to slide laterally across the chain and engage the spaces on the adjacent cone. The gear is designed to run with the slack side of the chain uppermost.

When it is desired to alter the speed ratio between the two shafts, the cones are moved by the lever, causing the chain to rise or fall automatically in the V, while at the same time the two other cones are spread or brought together giving infinite speed changes within the range of the gear. The arrangement is exceedingly compact and it is expected that it will find application to motor vehicles. For example, the 5-hp. standard unit is contained in a box 20½ by 13½ by 10 in. and with the input shaft running at 750 r.p.m. allows any speed between 300 and 1800 r.p.m. to be given to the output shaft. It is also of interest in the control of speed of mechanical stokers, coal and ash-handling equipment, pulverized fuel feeders and draft equipment, presenting possibilities of obtaining variable speeds with a.c. motors for such work.

Engineering Foundation Tests Experimental Dam

IN ONE OF THE rocky canyons of the high Sierras, on Stevenson Creek, near Fresno, Calif., an arch dam 60 ft. high of Portland cement concrete has been built wholly for experimental purposes by a committee of the Engineering Foundation, the committee, headed by Prof. Charles D. Marx of Stanford University, being composed of members of the American Society of Civil Engineers. Although many tests have been made and valuable information obtained, months of work are still ahead to secure all the information which the above committee on Arch Dam Investigation hopes to get from the experiment. Building and testing this dam is costing about $110,000.

Even when the reservoir was filled so full of water that it flowed over the top of the dam the structure did not break. In order to cause it to break it may be necessary to build it up many feet at an additional cost of about $1000 a foot of height.

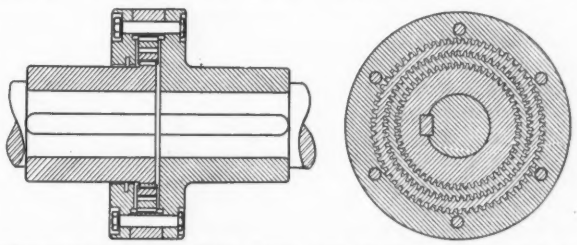
The reservoir back of the dam can be filled not only from the water of the creek but also from one of the great water supply tunnels of the Southern California Edison Co. which pierces the mountain just above this reservoir. Consequently, it is possible to fill and empty the reservoir back of the dam in a short time and to make experiments at will under full control.

Water was first let into the reservoir for test purposes to a depth of 10 ft. on July 1, 1926. In all, 13 load tests have been made to date, the last one with the water level with the top. Tests were made at night so that the temperature changes would be least during the long periods required for making and recording the observations.

Some of the measurements appear to differ from expectations based on prior practice and theory. Mature consideration must be given not only to the immediate results of tests on the experimental dam but also to special tests of concrete and instruments made in the laboratories of the University of California, California Institute of Technology, Bureau of Standards and the Portland Cement Association, not to mention observations of other dams now in service and data from all sources.

Flexible Coupling Employs Hubs and Floating Rings

IN A NEW FLEXIBLE coupling just placed on the market, several interesting features are found. This coupling consists of two hubs fitted and keyed to the two shafts, one of the hubs having hobbed claws somewhat similar to gear teeth, although not of a gear tooth profile; the other hub has bolted to it an internally-hobbed member; there are two or more floating rings, one of which is split in two with claws on the inside and outside circumferences interposed radially between the two first-mentioned members, the whole assembly being tightly closed and lubricated by means of grease injected through an Alemite connection in the side of the coupling.



SECTIONS SHOWING HOW HUBS ARE CONNECTED BY FLOATING RINGS WITH HOBBED CLAWS

This coupling, devised by J. Y. Dahlstrand, of Standard Turbine Corp., Scio, N. Y., is made of steel throughout and designed for a high operating speed without danger of breakage. It is designed entirely free to move endways to the extent of ¼ in. without imposing any end-thrust on either of the rotors and to permit of a considerable degree of angular misalinement.

It is claimed that it will take care of a certain degree of lateral misalinement, in which case all of the claws will not be engaged at one time but, since the claw surface is in excess of four times that necessary to transmit the load which can be carried by a certain shaft diameter, this coupling is designed to transmit any loads imposed.

Alinement of this coupling can readily be checked, as the only thing necessary is the measurement of the clearance at point "A" with a gage furnished with the coupling. The coupling can be disconnected so as to allow operation of the prime mover without running the driven machine, or vice versa.

A. I. E. E. Nominates New Officers

IT HAS just been announced by the National Nominating Committee of the American Institute of Electrical Engineers that Bancroft Gherardi, vice president and chief engineer of the American Telephone & Telegraph Company, has been nominated for the office of president of the American Institute of Electrical Engineers for the coming year.

Mr. Gherardi was born in San Francisco, Calif., April 6, 1873, and was graduated with the degree of B.S. in the Polytechnic Institute of Brooklyn in 1891 and from Cornell University with the degree of M.E. in 1893 and degree of M.M.E. in 1894.

He entered the employ of the New York Telephone Company in 1895 and in 1899 was made traffic engineer of that company. In 1901 he became chief engineer of the New York & New Jersey Telephone Company, serving in that capacity until 1906, when he was made assistant chief engineer of the New York Telephone Company and New York & New Jersey Telephone Company. In 1907 he was appointed equipment engineer of the American Telephone & Telegraph Company and in 1909, engineer of plant, in which capacity he served until 1918, when he was appointed acting chief engineer and shortly thereafter chief engineer. In April, 1920, he became vice president and chief engineer of the American Telephone & Telegraph Company.

Mr. Gherardi's activities with the American Institute of Electrical Engineers are as follows: Associate 1895; Fellow 1912; Manager 1905-08, 1914-16; Vice President 1908-10.

Others nominated for office for the coming year are as follows: For Vice Presidents: middle eastern district—J. L. Beaver, Associate Professor of Electrical Engineering, Lehigh University, Bethlehem, Pa.; southern district—C. O. Bickelhaupt, Vice President, Southern Bell Telephone & Telegraph Co., Atlanta, Ga.; north central district—O. J. Ferguson, Dean, College of Engineering and Professor of Electrical Engineering, University of Nebraska, Lincoln, Nebr.; Pacific district—E. R. Northmore, Superintendent of Electric Distribution, Los Angeles Gas & Electric Corp., Los Angeles, Calif.; Canada district—A. B. Cooper, General Manager, Ferranti Electric Limited, Toronto, Ont.

For managers: F. C. Hanker, manager, Central Station Engineering, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.; H. P. Liversidge, vice president and general manager, Philadelphia Electric Co., Philadelphia, Pa.; E. B. Meyer, chief engineer, Public Service Production Co., Newark, N. J.

For treasurer: Geo. A. Hamilton, electrical engineer (retired), Elizabeth, N. J.

Midwest Power Conference to Be Held Feb. 15-18

JUDGING BY the preliminary announcements of the committee on general arrangements for the Midwest Power Conference, which is to be held at Chicago, February 15 to 18, 1927, the conference will be replete with interesting addresses and discussions by many men prominent in the power industry.

The conference opens on Tuesday afternoon February 15 with an address by the chairman, followed by an address on a topic of general interest to the power field, which has not yet been announced.

The papers to be delivered on Wednesday, February 16, the second day, will be devoted to the general subject of use of power in industries. On Wednesday morning the papers will cover the use of power in steel mills, in a corn products factory and in paper mills; the afternoon papers will cover cement mills, the packing industry and one or two others.

On Thursday morning, February 17, a prominent public utility executive will discuss the "Development of Gas Production and Its Effect on Electric Power Supply"; Thursday afternoon will be devoted to inspection trips.

On Friday morning, February 18, a paper will be given on "Coal for Central Power Plants" and another on "Recent Developments in Coal Burning"; Friday afternoon will also be devoted to inspection trips. The usual banquet will be held on Friday evening.

Arrangements have been made by the committee for inspection trips on Thursday and Friday afternoons, as noted, to the Illinois Steel Co., South Chicago; the Calumet station of the Commonwealth Edison Co.; the plant of Crane Co.; and that of By-Products Coke Co. The above program is, of course, more or less tentative and the complete program with the names of the speakers will be announced later.

Stone & Webster Forms New Company

STONE & WEBSTER, INC., and Blodget & Co., announce the formation of a new company under the name of Stone & Webster & Blodget, Inc. The company will begin operations on Jan. 1, 1927, with an authorized capital of $10,000,000.

The corporation is a combination of the securities department of Stone & Webster, Inc., and the old investment house of Blodget & Co. The engineering and construction, management, and investigating departments of Stone & Webster, Inc., are not included and will not be affected by the combination. The consolidation follows the trend of amalgamation in other fields, being one of the first of importance in the investment banking business.

Bayard F. Pope, now a partner of Blodget & Co., will be president of the new corporation. Other officers and the directors will be drawn from both the participating companies, all the present partners of Blodget & Co. being officers of Stone & Webster & Blodget, Inc. The head offices of the new company will be at 120 Broadway. Each company has been maintaining offices in New York, Boston and Chicago. They will be consolidated in each city under the new plan and C. E. Ober, now of Blodget & Co., as senior vice-president, and R. H. van Deusen, now of Stone & Webster, Inc., as vice-president, will have charge of the business of the new corporation in these cities respectively. Other offices, which are now maintained in Providence, R. I., Hartford, Conn., Rochester and Albany, N. Y., and Portland, Me., will be included in the combination and will continue operation.

Stone & Webster & Blodgett, Inc., will offer a complete service both to investors and to issuers of securities.

Edison Medal Awarded to William D. Coolidge

IT HAS RECENTLY been announced by the Edison Medal Committee of the American Institute of Electrical Engineers that the Edison medal for the year 1926 has been awarded to Dr. William D. Coolidge for the origination of ductile tungsten and the fundamental improvement of the X-ray tube. The Edison medal was founded by associates and friends of Thomas A. Edison and is awarded annually for meritorious achievements in electrical science, electrical engineering or the electrical arts by a committee consisting of 24 members of the American Institute of Electrical Engineers.

William David Coolidge, assistant director of the research laboratory of the General Electric Company, physical chemist, was born in Hudson, Massachusetts, October 23, 1873, the son of Albert Edward and M. Alice Coolidge. Dr. Coolidge is a graduate of the Massachusetts Institute of Technology, B.S., 1896, and of the University of Leipzig, Ph.D., 1899. He has been assistant in physics, instructor in physical chemistry and assistant professor of physico-chemical research of the Massachusetts Institute of Technology. Dr. Coolidge became associated with the General Electric Co. in 1905 and became assistant director of the research laboratory in 1908. He was awarded the Rumford medal in 1914 for invention and applications of ductile tungsten. Dr. Coolidge is a member of the American Chemical Society, American Electrochemical Society, American Physical Society, American Institute of Electrical Engineers, American Academy of Arts and Sciences, Washington Academy of Sciences. He is an honorary member of the American Roentgen Ray Society, American Radium Society, Radiological Society of North America, Roentgen Society (of England), Societe de Radiologie Medicale (of France), and Nordick Forening for Medicinsk Radiologi.

Engineering Building for Chicago

FOR MANY years the need for a center of engineering activity where engineering matters of all kinds can be liberally discussed has been apparent to the engineers of Chicago. A number of attempts have been made to supply this need but due to the difficulties of financing so large a project none of these attempts have matured until the building illustrated herewith was offered for this purpose.

Coffey and McKeown of 1448 Straus Bldg., Chicago, announces the building of a $6,000,000, 23-story, magnificent gothic structure which is to be used for engineering and allied activities. The exterior will be of Bedford stone and the lobby will follow gothic design in accordance with the general scheme of architecture. The building will face on Wells street, with a frontage of 100 ft., and 150 ft. on Wacker drive. There will be three sub-basements. The floors below the upper level will be used for garage purposes so that tenants may have parking facilities for their cars. Zachary T. Davis is the architect of the building. Occupancy is announced for May 1, 1928.

The Western Society of Engineers has leased space representing nearly double the space it now occupies. This will permit of not only more adequate quarters for the offices and for the establishment of conference rooms, but will permit of better housing of the library, which is the largest engineering library west of New York City. National Engineering Societies, located in Chicago, have already leased space in the building, and local sections of National Engineering Societies whose national homes are located in other cities will hold their meetings in the new Engineering Building. The Society of Industrial Engineers has leased space in the building.

GOTHIC SHAFT TO HOUSE ENGINEERING ACTIVITIES IN CHICAGO

An auditorium, seating at least 500, will be provided for meetings. The societies located in the building will have the privilege of using this auditorium. The entire lower level has been leased to one concern for 10 yr., and a number of engineering firms have already signed up for space in other parts of the building.

Chicago is to be congratulated on the projected establishment of this magnificent monument as a visible sign of the place engineering now holds in our national life, as well as for the means it offers for both broadening and deepening engineering activities.

THE NEW JERSEY POWER & LIGHT CO., Dover, N. J., operated by the General Gas & Elec. Corp., New York, has been authorized to carry out its projected general expansion plans. Among these are plans for a new steam power plant at Holland on the Delaware River, about 8 mi. from Easton, Pa.

News Notes

AT THE ANNUAL MEETING of the American Engineering Standards Committee on December 9, Charles E. Skinner, a representative of the A.I.E.E., was re-elected chairman for the year 1927 and Charles R. Harte, representative of the A.E.R.A., was re-elected vice chairman. Other members of the executive committee were chosen from representatives of all the national engineering societies, the various departments of the United States Government and other interested groups.

REPORT OF the 1926 annual convention of the American Institute of Steel Construction, Inc., held Oct. 26 to 30, at White Sulphur Springs, contains several of the important papers that were presented. The report of the Technical Research Committee states that investigations are being carried on in the subjects of welding of structural steel, wind bracing, fire-proofing and protection of steel against corrosion.

THE NEW YORK STATE ASSOCIATION of the N.A.S.E. will have a bill introduced at the next session of the New York State Legislature to provide for licensing stationary engineers in that state.

ACCORDING TO the British Consulate General, Chicago, the British Industries Fair for 1927 has been set for February 21 to March 4. The fair is divided into two sections; the general section in London and the engineering section in Birmingham. The engineering section will be even larger than that of last year, which proved extremely successful. The 25 firms that recently co-operated in the erection of the "Perfect Boiler House" are arranging to repeat this demonstration at the fair.

THE BURKE ELECTRIC CO., Erie, Pa., manufacturer of motors, generators and welding equipment, announces the appointment of H. C. Lemire, 407 South Fourth street, Minneapolis, Minn., as district sales agent for Minnesota, the Dakotas and the northern part of Wisconsin.

BUFFALO FORGE CO. and Buffalo Steam Pump Co. announce that, beginning Jan. 1, 1927, their Philadelphia office, in the Land Title Bldg., will be in charge of W. S. Koithan and R. W. Pryor, Jr., who for many years have been joint managers of the New York office. They will continue to manage the New York district with an enlarged engineering organization.

THE JOHNS-PRATT CO., which for some time has been controlled by and carried on as a division of the Colt's Patent Fire Arms Mfg. Co. of Hartford, Conn., is to be absorbed by the latter company and products heretofore manufactured and marketed under the name of the Johns-Pratt Co. will be handled by the Colt's Patent Fire Arms Mfg. Co. The same products and brands which have been made will be combined.

GEORGE SIMPSON, formerly chief engineer of the Poole Engineering & Machine Co., Baltimore, Md., died on December 18 at the age of 79. As a young man he went to work for his uncle, the late Robert Poole, founder of Poole & Hunt, now the Poole Engineering & Machine Co. His marked mechanical ability developed rapidly and in a few years he became chief engineer of the company, remaining until 1896. He spent the next 5 yr. as supervising engineer for the Farrel Foundry & Machine Co. and then returned to the Poole Co. as consulting engineer. He is survived by one brother, Robert Poole Simpson, former president of this company.

FRANK R. WHITE, in charge of advertising and sales correspondence for The Fisher Governor Co., Marshalltown, Ia., died on Sunday, December 26, at Marshalltown following an operation.

Mr. White was born in Stark County, Ill., in 1884, going to Marshall County, Iowa, in 1896. He joined The Fisher Governor Co. 8 yr. ago in the cost accounting department and about 4 yr. ago was advanced from this position to a position in the sales department, gradually taking on added responsibilities until he had charge of the advertising department and the sales correspondence.

AT ITS MEETING in New York City on December 30, 1926, the board of directors of the General Electric Co. elected Theodore Beran of New York, H. L. Monroe of Chicago and J. A. Cranston of San Francisco as commercial vice presidents, in charge of the commercial activities of the company in the New York, Central and Pacific Coast districts respectively. E. W. Allen, manager of engineering, was elected vice president in charge of engineering, with offices in Schenectady. On account of the temporary absence of Vice President F. C. Pratt because of illness, G. E. Emmons, former vice president, was elected as acting vice president to take charge of manufacturing activities.

ANNOUNCEMENT IS MADE that the firm of Cahill & Douglas, engineers, of Milwaukee, Wis., has been dissolved and that a general engineering business will be conducted by Chas. A. Cahill & Sons at 227 West Water street, Milwaukee. The latter organization is prepared to do work in all branches of civil, mechanical, electrical and electrical and industrial engineering but will not act as sales engineer.

THE ALLEN-SHERMAN-HOFF CO., Philadelphia, Pa., announces that it is to be represented by D. H. Skeen & Co., Chicago, Ill., in the Chicago territory and that a specialist in ash-handling work will devote his entire time to this service.

TENSION MOTOR BASE CO. of New York is putting on the market a spring-tension base for motors, which has been used abroad for several years. The purpose is to absorb vibration and keep even tension on the belt, this tension being adjustable while the motor is running.

LIBERTY ELEC. CORP., Stamford, Conn., manufacturer of the Liberty valve operator, announces the appointment of Himelblau, Agazim & Co., 30 North Dearborn street, Chicago, Ill., as its Chicago representative.

SARCO CO., INC., New York City, has recently supplied to some of the leading manufacturers of glue and gelatin a new temperature regulated chill bath for use in the testing of glue and gelatin samples. The results obtained with this control, which was designed by F. S. Williams, of Baugh & Sons Co., and remodeled by Dr. J. R. Powell, of Armour Glue Works, have been most successful. In the testing of these materials it is necessary to maintain a uniform temperature for a period preceding the tests and even a slight variation in temperature will affect the jell structure and result in inaccurate results.

The chill bath consists of two chambers, one to take ice or brine coils and the other fitted with a water circulating system surrounding a number of small glasses containing the samples. A Sarco temperature regulator is used for control and in an extended test of 100 hr. on one of these baths there was no change for temperature setting of 10 deg. C. greater than one-tenth of 1 deg. C. plus and minus and this accuracy of control can be definitely guaranteed.

THE AMTORG TRADING CORP. announced recently that Col. Hugh L. Cooper has sailed for Moscow to discuss with the Supreme Economic Council a contract for the proposed hydro-electric project on the Dnieper river in Soviet Ukraine. This plant is expected to have an initial capacity of 150,000 hp. with an ultimate capacity of 650,000 hp. and the project includes the building of an extensive irrigation system. The contract to be discussed is on the same general basis as that under which Col. Cooper built Muscle Shoals.

ACCORDING TO the latest report of the Department of Commerce, a total of 85 stokers under boilers totaling 27,606 hp. were sold by 12 establishments during November, 1926. This compares with a total of 76 stokers under 33,461 b.hp. sold by 13 establishments in November, 1925. Of the 85 stokers sold in November, 1926, 25 were under fire tube boilers of 3080 hp. total capacity and 60 stokers were under water tube boilers with a total of 24,526-hp. capacity.

ROCHESTER (N. Y.) Gas & Electric Corp. has placed with the Austin Co. a contract for the construction of a new pole-casting plant to be 60 by 120 ft., with wooden bins for sand and gravel storage and a 2-t. crane for handling the finished poles. The building is to be completed in 30 working days, or about Feb. 1. The Rochester company is now using concrete poles exclusively and the new plant is planned to maintain an adequate supply.

JESSE H. NEAL, who for 11 yr. has served as executive secretary of The Associated Business Papers, resigned from that position effective January 1. Mr. and Mrs. Neal will leave on a six-months' Mediterranean trip in January. The Executive Committee of the A. B. P. has created a new office for the association, that of Managing Director, and appointed Frederick M. Feiker to this office. After January 1 the headquarters of the A. B. P. will be located at 52 Vanderbilt Ave., New York.

RECENTLY A WORTHINGTON Feather valve compressor used for air lift pumping by the Auburn (Ind.) Water & Light Works was shut down for overhauling after 6 yr. of continuous 24-hr. service. The original valves were in this compressor during the entire period, during which time the unit had made approximately 1,134,000,000 strokes. When removed, the valves were found to be still serviceable and capable of operating with high efficiencies.

EARLY CONSTRUCTION of an important water power development at Chippewa Falls on the Chippewa River by the Northern States Power Co. was announced by H. M. Byllesby & Co. The Chippewa Falls plant, which will be built under the supervision of Byllesby Engineering & Management Corp., will have a capacity of 24,000 hp. in 6 units of 4000 hp. each. The dam and power house will be located about 2 mi. below the present development at Wissota. It will utilize existing storage facilities created by the Wissota project, operating synchronously with the latter and tieing in with the company's extensive transmission system. Construction work will be begun at an early date.

THE BUREAU OF YARDS AND DOCKS, Navy Dept., Washington, D. C., has called for bids on steam power plant equipment for the Navy hospital, Mare Island, Cal., as per specification No. 5252.

THE SOUTHERN CITIES UTILITIES CO., Chattanooga, Tenn., is planning a new steam power plant at Estill Springs, to have an initial output of about 20,000 hp. and to be ready for service in the summer of 1927.

THE POTOMAC EDISON CO., Cumberland, Md., has begun the construction of an addition to its steam power plant at Williamsport on the Potomac River to triple the present capacity. A new generating unit of 40,000-hp. capacity will be installed, with auxiliaries.

THE GENERAL PURCHASING OFFICER, Panama Canal, Washington, D. C., is asking bids until January 11 for a quantity of power and pumping equipment for Canal Zone service, including a generating plant, pumps, motors, electrical equipment and accessories, as per Panama circular 1775.

THE GEORGIA POWER CO., Atlanta, Ga., recently formed to take over and consolidate a number of utilities in Georgia, is planning to increase existing power facilities, transmission lines and substations. A large portion of the proposed $45,000,000 bond issue of this company will be used for this work.

Books and Catalogs

HYDRAULICS. Joseph N. LeConte, Prof. of Engineering Mechanics, Univ. of California, published in New York, 348 pages, $3.00.

Theoretical hydraulics presented from the standpoint of basic principles rather than empirical rules, tables or diagrams, on the assumption that, after mastering the fundamentals by the use of pure mathematics, mechanics and fundamental reasoning, the empirical simplification of methods will be obvious and easily applied.

Hydrostatics, hydraulics and hydraulic machinery are covered in the three divisions of the book. The first part covers the fundamental laws of mechanics as applied to hydrostatics. The second part takes up the hydraulics of a perfect liquid, free discharge, constrained discharge, flow through closed conduits in series, divided or parallel and variable flow in pipes, flow in open channels and methods of water measurement. In Part III hydraulic machinery, including the jet wheel, turbines, centrifugal pump and jet pump are considered as simple diagrammatic representation of the machines.

In a subject which must of necessity be treated mathematically a familiarity with differential and integral calculus, elementary analytical mechanics and some knowledge of hydraulic machinery has been assumed in the preparation of the book.

Developments are in all cases carried from funda-

mental principles clearly illustrated by simple sketches and thoroughly explained so that there should be little difficulty in following the work through. At the end of each chapter a number of problems are given, together with the correct answer so that the reader may apply the knowledge gained in the preceding pages.

This book should be of great value to those seeking a familiarity with the fundamentals as well as engineers who are investigating a particular phase of the subject.

"PHYSICAL PROPERTIES OF NICKEL and Nickel Chromium Steels" is the subject of bulletin No. 9 recently issued by The International Nickel Co. of New York City. This bulletin was compiled by the development and research departments of the company and contains curves showing the average values of tensile strength, elastic limit, reduction of area, elongation and Brinell hardness at various drawing temperatures for the S. A. E. standard nickel and nickel chromium steels. Tables of maximum and minimum values of these same properties reported by various authorities are also given, together with causes of variations and notes on the use of the data in design.

CHICAGO CHEMICAL CO., Chicago, Ill., in a recent bulletin, discusses its water testing equipment for laboratory and power plant use. Various types and sizes of testing kits for use with the K. W. S. method of treating boiler feed water are described and instructions given for their use.

Other bulletins of the company discuss standard methods of water analysis and interpretation of results, how to control blowdowns, the use of sodium aluminate in the manufacture of ice and many other subjects of interest to the power plant engineer.

QUIGLEY FURNACE SPECIALTIES CO., New York City, in a recent well illustrated 24-page bulletin, illustrates and describes applications of "Hytempite" in refractory construction and maintenance. The use of crushed old fire brick for patching and rebuilding furnace walls, making monolithic baffles and special tile is discussed, together with tables of correct mixtures and methods of application. The use of the Quigley refractory gun in applying plastic refractory materials is given in some detail.

GENERAL ELECTRIC dynamometers for the measurement of torque or power are described in bulletin GEA-544 of the General Electric Co.

WHAT USERS Say of Adamant fire brick and suggestions for longer service are contained in a pamphlet just received from Botfield Refractories Co., Swanson and Clymer Sts., Phila, Pa.

MIDWEST STEEL & SUPPLY CO., Inc., Bradford, Pa., has recently issued a folder describing a device called "Ventex" which is installed in cans, tanks or other containers used for holding inflammable liquids, such as gasoline, benzine, naphtha, ether and similar explosive liquids for preventing fires and explosions.

IN CO-OPERATION with the General Electric Co., The Bigelow Co. has developed the Bigelow electric steam generator as described in its latest circular. This is made in sizes from 12 to 250 kw. and the bulletin states that it is approximately correct to determine the boiler horsepower rating of this generator by dividing the kilowatt size of the unit by 10. It is supplied for 110 and 220 v. in the smaller sizes and 220 and 440 v. in the larger sizes. The unit is designed for 100 lb. working pressure according to the A.S.M.E. boiler code requirements. Standard equipment includes electrical control and safety valve, steam gage, water gage and other steam accessories.

FOSTER WATER BACKS are described in bulletin No. 262 by Power Specialty Co., New York City. These are made up of seamless steel tubes to which are shrunk cast-iron refractory blocks.

SCHUTTE & KOERTING CO., Philadelphia, Pa., has just published its bulletin 8-R dealing with reducing valves and regulators. This bulletin gives some interesting and valuable engineering information, which should be of aid to engineers in selecting reducing valves for various industrial uses.

B. F. STURTEVANT CO., Boston, Mass., in bulletin No. 346 describes its new propeller type forced draft fan designed for application to larger types of boilers. This fan can be installed right at the windbox, eliminating ducts, and is offered in capacities up to 40,000 c.f.m. at 5-in. static pressure. This company has also issued bulletin No. 347 describing its new tubular air heater with lead-coated tubes and stuffing box arrangement to prevent leakage around the movable tube sheet. Bulletin No. 348 describes the Turbovane fan as developed for induced draft work.

INGERSOLL-RAND CO., New York, has issued catalog No. 9027, first edition, describing and illustrating in great detail the Ingersoll-Rand condenser. This bulletin discusses the heart-shaped shell and the tube staging, together with the method of sectionalizing the condenser to give proper longitudinal steam distribution. Many interesting steam flow diagrams and installation views, together with a detailed discussion of general condenser design are given.

"THE STORY OF KRUZITE & MIZZOU SUPER-REFRACTORIES" is the title of a booklet just issued by A. P. Green Fire Brick Co., Mexico, Mo. This little booklet is well illustrated with halftone cuts and line drawings to show the source of refractory materials and the plants used in their manufacture.

THE BROWN HOISTING MACHINERY CO., Cleveland, Ohio., has issued its 1927 wall calendar which illustrates a number of large fuel and material-handling cranes.

THE KOPPERS CO., Pittsburgh, Pa., is distributing a wall calendar for the coming year. This calendar illustrates various installations of their by-product coke apparatus.

THE NATIONAL TUBE CO.'S wall calendar for 1927 illustrates in color, the rolling of one of the steel tubes made by this company. It is being distributed from the Pittsburgh, Pa., office.

THE DELAVERGNE MACHINE CO., of 978 East 138th street, New York City, has issued a wall calendar illustrating its various large Diesel engines, and is distributing it to interested engineers.

L. H. JENKINS, INC., edition book manufacturers, of Richmond, Va., have issued a large wall calendar having large and prominent figures.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

The Fires of Prosperity are Burning Higher

Fuel consumption in 1926 shows a large increase over that of 1925, according to government figures and authoritative estimates for the latter part of 1926.

Oil production is higher and coal production has continued to go up.

Regardless of the more general use of oil as a fuel and of the development of water power, coal is approximately seven-eighths of the fuel used in the manufacture and distribution of goods.

If coal is being used even 10 per cent more than in the past, it is fair to assume that there is a very large increase in the function of manufacturing, selling and distributing products that constitute the commercial life of the nation and that are the sound basis of a steadily growing prosperity.

Along with the increasing use of fuel, rapid progress constantly is being made in getting more power, heat and light from each pound of fuel. Together these two mighty factors are grinding a golden grist of material prosperity.

All this might be economically unsound and even dangerous to the future of the social structure except for the fact that this great increase of wealth, products and conveniences is being shared by all the people.

Never in the history of this nation were its markets so largely made up of supplying the needs of its own people. Never were all our enterprises so generally financed by our own capital. Never were our raw products so largely drawn from our own natural resources.

Today this nation is the greatest self-contained economic entity in history.

This material success is bound to increase and to promote a higher civilization than ever before because the people of this nation have learned how to use prosperity.

Wealth concentrated in the hands of castes, aristocracies and royal families has glorified ancient capitals through patronage of learning and the fine arts. Wealth in the hands of the people who work for it glorifies all the people, uplifts them and develops their abilities to do fine things and their faculties to enjoy the finer things of life.

Year by year as mechanical power reduces the drudgery of life, mankind finds the time, resources and facilities to enjoy and to learn from the accumulating beauties of thought-expression and to explore Nature's beckoning charms.

Today, the generation of tomorrow has before its childhood, a wealth of opportunity for knowledge and cultivation greater than that offered any royal prince of olden times.

Such a civilization must go on. Prosperity created by the more economical use of earth's resources, by more scientific administration of human affairs and by better workmanship, develops the race. Prosperity that is distributed to the people who work and whose accumulated surplus creates the capital used in their work, furthers this great uplifting movement. Prosperity that continues to be absorbed in better living and higher cultivation cannot be denied, stopped or hindered by any force or movement that can possibly arise.

But what are we going to do with this immediate prosperity?

These are strenuous times. For the men who have not yet put their careers behind them; especially for men responsible for power plants, sounder judgment, greater enterprise and more alert action are demanded than ever was required in periods when times were hard.

In the same proportion that this prosperity is sound, so is it competitive. Holding out, as it does, greater opportunities than before, it has accelerated the pace, speeded the race, for preferment, for material profits, and for more profitable living.

What plants will generate the power of the future; what men command them? These questions are being answered by the records of today.

What stokers, grates and furnaces will be burning the millions of tons of fuel to be consumed in 1927? What equipment, machinery and supplies will transform the heat from this coal into power, heat and light?

On the selection of these in great measure depends the future of power plants and of the men who shall build, equip and operate them.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago, Ill.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Murray Iron Works Co., Burlington, Iowa.
Nordberg Mfg. Co., Milwaukee.
ery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago.

AIR WASHERS.
Buffalo Forge Co., Buffalo, N. Y.
New York Blower Co., Chicago.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.

ARCHES, BOILER AND COMBUSTION.
Betson-Jewell, Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Burke Engineering Co., Holland, Mich.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., New York.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hoftt Co., The M. A., Indianapolis, Ind.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialtes Co., Inc., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., New York.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., New York.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Conveyors Corp. of America, Chicago.

BABBITT METAL.
Magnolia Metal Co., New York.

BAROMETERS.
Taylor Inst. Co.'s, Rochester.

BEARING METAL.
Magnolia Metal Co., New York.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Jeffrey Mfg. Co., The, Columbus, O.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING.
New York Belting & P'k'g Co., New York.
Quaker City Rubber Co., Philadelphia.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Air Preheater Corp., The, New York.
Buffalo Forge Co., Buffalo.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
New York Blower Co., Chicago.
Robinson Ventilating Co., Zelienople, Pa.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
McClave-Brooks Co., Scranton, Pa.
New York Blower Co., Chicago.
Robinson Ventilating Co., Zelienople, Pa.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE.
Buffalo Steam Pump Co., Buffalo, N. Y.
Sturtevant Co., B. F., Hyde Park, Mass.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo
Robinson Ventilating Co., Zelienople, Pa.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, PULVERIZED COAL.
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM.
Schutte & Koerting Co., Philadelphia.

BLOWERS, PRESSURE.
Robinson Ventilating Co., Zelienople, Pa.

BLOWERS, TUBE.
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Robinson Ventilating Co., Zelienople, Pa.

BLOWERS, TURBINE.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson-Jewell, Inc., Rome, N. Y.
Boiler Engr'g. Co., Newark, N. J.
Engineer Co., The, New York,
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER CASING.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER COVERINGS.
Celite Products Co., New York.

BOILER ENGINEERS.
Boiler Engr'g. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.

BOILER FRONTS.
McClave-Brooks Co., Scranton, Pa.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson-Jewell, Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Insulating Products Corp., New York, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 162

BOILER SETTINGS.
Betson-Jewell, Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Walsh Fire Clay Products Co., St. Louis, Mo.
Webster, Howard J., Philadelphia, Pa.

BOILER TUBE CLEANERS.
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Celite Products Co., New York.
Insulating Products Corp., New York, N. Y.

BOILERS,
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor, Del.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Nuway Boiler & Engineering Co., Chicago.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw.

BOOKS AND SCHOOLS.
Hays Institute, The, Chicago, Ill.
McGraw-Hill Book Co., New York.

BRICKS, FURNACE LINING.
Celite Products Co., New York.
Norton Co., Worcester, Mass.

BREECHINGS.
Connery & Co., Inc., Philadelphia.

BRUSHES, DYNAMO AND MOTOR.
Calebaugh Self-Lubricating Carbon Co., Inc., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Jeffrey Mfg. Co., The, Columbus, O.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., The, Columbus, O.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET.
Jeffrey Mfg. Co., The, Columbus, O.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Fuller - Lehigh Co., Fullerton, Pa.
Girtanner Engrg. Corp., New York.
Hills - McCanna Co., Chicago.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson-Jewell, Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
Insulating Products Corp., New York, N. Y.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT GUNS.
Cement-Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Insulating Products Corp., New York, N. Y.
Johns-Manville Corp., New York.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Specialties Co., Inc., New York.